

10/587342

IAP5 Rec'd PCT/PTO 25 JUL 2006

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Наш № 20/12-397

«11» июля 2006 г.

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2420-300684

1/3

## PCT REQUEST

Original (for SUBMISSION )

0	For receiving Office use only	
0-1	International Application No.	PCT / RU 2005 / 000559
0-2	International Filing Date	11 November 2005 (11.11.2005)
0-3	Name of receiving Office and "PCT International Application"	<b>RO/RU</b> <b>МЕЖДУНАРОДНАЯ ЗАЯВКА PCT</b> <b>PCT INTERNATIONAL APPLICATION</b>
0-4	Form PCT/RO/101 PCT Request	
0-4-1	Prepared Using	PCT-SAFE [EASY mode] Version 3.50 (Build 0002.173)
0-5	Petition The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty	
0-6	Receiving Office (specified by the applicant)	Federal Service on Intellectual Property, Patents and Trademarks (Russian Federation) (RO/RU)
0-7	Applicant's or agent's file reference	2420-300684
I	Title of Invention	GRAPHICAL USER INTERFACE (GUI) NOISE REDUCTION IN A COGNITIVE CONTROL FRAMEWORK
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11 НОЯ 2005  
ВХОД. ОТА. 17

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2420-300684

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## PCT REQUEST

Original (for SUBMISSION)

IV-1	Agent or common representative; or address for correspondence The person identified below is hereby/ has been appointed to act on behalf of the applicant(s) before the competent International Authorities as:	<b>agent</b>	
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V	DESIGNATIONS		
V-1	The filing of this request constitutes under Rule 4.9(a), the designation of all Contracting States bound by the PCT on the international filing date, for the grant of every kind of protection available and, where applicable, for the grant of both regional and national patents.		
VI-1	Priority Claim	<b>NONE</b>	
VII-1	International Searching Authority Chosen	<b>European Patent Office (EPO) (ISA/EP)</b>	
VIII	Declarations	Number of declarations	
VIII-1	Declaration as to the identity of the inventor	-	
VIII-2	Declaration as to the applicant's entitlement, as at the international filing date, to apply for and be granted a patent	-	
VIII-3	Declaration as to the applicant's entitlement, as at the international filing date, to claim the priority of the earlier application	-	
VIII-4	Declaration of inventorship (only for the purposes of the designation of the United States of America)	-	
VIII-5	Declaration as to non-prejudicial disclosures or exceptions to lack of novelty	-	
IX	Check list	number of sheets	electronic file(s) attached
IX-1	Request (including declaration sheets)	3	✓
IX-2	Description	25	-
IX-3	Claims	6	-
IX-4	Abstract	1	✓
IX-5	Drawings	10 <sup>15</sup>	-
IX-7	TOTAL	35 <sup>15</sup>	

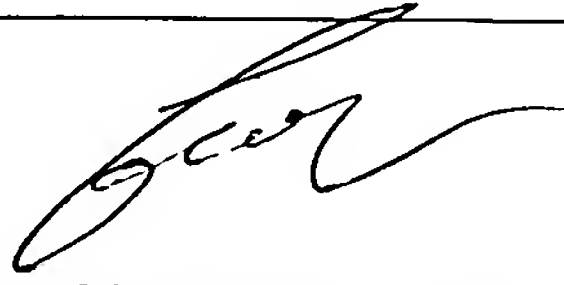
88, 8  
 RU/RU

2420-300684

3/3

## PCT REQUEST

Original (for SUBMISSION )

	Accompanying Items	paper document(s) attached	electronic file(s) attached
IX-8	Fee calculation sheet	✓	-
IX-17	PCT-SAFE physical media	-	✓
IX-19	Figure of the drawings which should accompany the abstract		
IX-20	Language of filing of the international application	English	
X-1	Signature of applicant, agent or common representative	 LAW FIRM "GORODISSKY & PARTNERS" LTD. Galina Egorova Chief of Filing Department	
X-1-1	Name		
X-1-2	Name of signatory		
X-1-3	Capacity		

## FOR RECEIVING OFFICE USE ONLY

10-1	Date of actual receipt of the purported international application	II November 2005 (II.II.2005)
10-2	Drawings:	X
10-2-1	Received	
10-2-2	Not received	
10-3	Corrected date of actual receipt due to later but timely received papers or drawings completing the purported international application	
10-4	Date of timely receipt of the required corrections under PCT Article 11(2)	
10-5	International Searching Authority	ISA/EP
10-6	Transmittal of search copy delayed until search fee is paid	

## FOR INTERNATIONAL BUREAU USE ONLY

11-1	Date of receipt of the record copy by the International Bureau	
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13-2-3	Validation messages Names	Green? Applicant 1:Telephone No. missing
	Validation messages Names	Green? Applicant 1:Facsimile No. missing
13-2-4	Validation messages Priority	Green? No priority of an earlier application has been claimed. Please verify
13-2-7	Validation messages Contents	Yellow! The power of attorney or a copy of the general power of attorney will need to be furnished unless all applicants sign the request form.
	Validation messages Contents	Green? The international application contains no drawings. Please verify.
13-2-8	Validation messages Fees	Green? Please confirm that fee schedule utilized is the latest available

## Graphical User Interface (GUI) Noise Reduction in a Cognitive Control Framework

5

### BACKGROUND

#### 1. FIELD

10 The present invention relates generally to automatic control of software application programs and image analysis and, more specifically, to analyzing graphical user interface (GUI) images displayed by an application program for automatic control of subsequent execution of the application program.

#### 15 2. DESCRIPTION

Typical application program analysis systems capture keyboard input data and mouse input data entered by a user. The captured input data may then be used to replay the application program. These systems rely on playback of the application program on the same computer system used to  
20 capture the input data, and thus are not portable.

Some existing application program analysis systems use image recognition techniques that are dependent on screen resolution and/or drawing schemes, or have strong dependencies to the underlying operating system (OS) being used. Such systems typically rely on dependencies  
25 such as Windows32 or X-Windows application programming interfaces (APIs). This limits their portability and usefulness.

Hence, better techniques for analyzing the GUIs of application programs are desired.

#### 30 BRIEF DESCRIPTION OF THE DRAWINGS

The features and advantages of the present invention will become apparent from the following detailed description of the present invention in which:

5           Figure 1 is a diagram of a cognitive control framework system according to an embodiment of the present invention;

          Figure 2 is a flow diagram illustrating processing in a cognitive control framework according to an embodiment of the present invention;

          Figure 3 is an example display of the GUI of an application program  
10          captured and saved during a recording phase;

          Figure 4 is an example display of the GUI of an application program captured during a playback phase;

          Figure 5 is an example image illustrating objects identified during  
15          contouring operations of the recording phase according to an embodiment of the present invention;

          Figure 6 is an example image illustrating objects of activity of the recording phase according to an embodiment of the present invention;

          Figure 7 is an example image illustrating objects identified during  
20          contouring operations of the playback phase according to an embodiment of the present invention;

          Figure 8 is an example image illustrating a hypothesis during the playback phase according to an embodiment of the present invention;

          Figure 9 is an example image illustrating a highlighted object according to an embodiment of the present invention;

25          Figure 10 is an example image illustrating an object with no highlighting according to an embodiment of the present invention;

          Figure 11 is an example image illustrating an active object according to an embodiment of the present invention;

30          Figure 12 is an example image illustrating an inactive object according to an embodiment of the present invention;

Figure 13 is an example image illustrating a tool tip in a recorded image according to an embodiment of the present invention;

Figure 14 is an example image illustrating a tool tip in a playback image according to an embodiment of the present invention;

5 Figure 15 is an example image illustrating an index structure in a first version of a GUI according to an embodiment of the present invention;

Figure 16 is an example image illustrating another index structure in a second version of a GUI according to an embodiment of the present invention;

10 Figure 17 is a flow diagram of noise reduction processing according to an embodiment of the present invention;

Figure 18 is an example image illustrating a recorded image according to an embodiment of the present invention;

15 Figure 19 is an example image illustrating a playback image according to an embodiment of the present invention;

Figure 20 is an example image illustrating another recorded image according to an embodiment of the present invention;

Figure 21 is an example image illustrating another playback image according to an embodiment of the present invention; and

20 Figure 22 is a flow diagram illustrating GUI noise reduction processing according to an embodiment of the present invention.

## DETAILED DESCRIPTION

25

Embodiments of the present invention comprise a cognitive control framework (CCF) for automatic control of software application programs that have a graphical user interface (GUI). Examples of such applications programs may be executed on current operating systems such as Microsoft  
30 Windows® and Linux, for example, as well as other operating systems. An embodiment of the present invention creates a system simulating a human

user interacting with the GUI of the application program and using the GUI for automatic control of the application program without relying on dependencies such as specific graphical libraries, windowing systems, or visual controls interfaces or implementations. The CCF comprises an easy-to-use cross-platform tool useful for GUI testing based on pattern recognition. By being independent of any OS-specific controls and graphical libraries, the CCF may be used for interaction with non-standard graphical interfaces as well as with well known ones. The system provides for recording any kind of keyboard and mouse actions the user performs while working with the GUI of the application program and then providing playback of the recorded scenario. In the present invention, image analysis of captured display data (such as screen shots, for example) is performed to identify actions of the application program corresponding to user input data. These actions and input data may be stored for use in future playback of the same user scenario for automatically interacting with the application program.

Embodiments of the present invention comprise operating on two phases: a recording phase and a playback phase. During the recording phase, the system is "learning" how to control the application program. The system registers and captures input actions supplied by the user (such as a mouse click or entering of text via a keyboard, for example) and display data (e.g. screen shots) of images displayed by the application program in response to those actions. The user actions, the time interval between actions, resulting display data of the GUI of the application program, and possibly other data and/or commands form an execution scenario. By following the execution scenario, during the playback phase the system provides the same but fully automatic execution of the application program (simulating the user control but without the real presence of the user). Automatic execution is made possible due to a plurality of image analysis and structural techniques applied correspondingly to images during the recording and playback phases.

Figure 1 is a diagram of a cognitive control framework (CCF) system 100 according to an embodiment of the present invention: Figure 1 shows two components, recording component 102 and playback component 104. These components may be implemented in software, firmware, or hardware, or a combination of software, firmware and hardware. In the recording component, the CCF system registers and captures user input activity at block 106. For example, the user may make input choices over time to an application program being executed by a computer system using a mouse, keyboard, or other input device. This input data is captured and stored by the CCF system. Next, at block 108, the display data may be captured (e.g. screen shots are taken). In one embodiment, the display data may captured only when user input has been received by the application program. The display data is also saved. At block 110, the data captured during blocks 106 and 108 may be analyzed and saved. These processes may be repeated a plurality of times. The result of the processing of the recording component comprises an execution scenario 112 for the application program being processed by the system. In one embodiment, the execution scenario comprises a script containing Extended Markup Language (XML) tags. The execution scenario describes a sequence of user inputs to the application program, corresponding display images on a GUI of the application program, and commands directing the application program to perform some actions.

At a later point in time, during the playback phase the playback component 104 may be initiated. At block 114, simulated user activity may be generated based on the execution scenario. That is, saved inputs and commands from the execution scenario may be input to the application program for purposes of automatic control using the CCF system. While the application program processes this data, display data may be changed on the display as a result. At block 116, the CCF system performs image analysis on the playback display data currently being shown as a result of application program processing and the display data captured during the

recording phase. At block 118, recorded time conditions may be checked to take into account possible variations in playback. For example, the time when an object appears may be within a time interval based on a recorded time. For example, in one embodiment a lower bound time (time to start the search) may be extracted from the saved data in the execution scenario and an upper bound time may be the lower bound time plus 10%, or some other appropriate value. Processing of blocks 114, 116, and 118 each result in data being stored in report 120. At block 119, the CCF system controls execution of the application program based on the results of the image analysis. Blocks 114, 116 and 118 may be repeated for each in a sequence of user input data items from the execution scenario.

The time interval between sequential actions is a part of the captured execution scenario. However, while following the execution scenario in the playback phase, one should not expect that the time interval between any two actions at playback will be equal to the time interval between the same two actions during the recording phase. There are a number of objective reasons why this interval could be different on playback than during recording. For example, the application program during recording and playback may be executed on different computer systems having different processor speeds, or an application program could require different times for the same actions during playback due to accesses of external data or resources. This indicates a requirement in the CCF system to handle flexible time conditions, e.g. handle some tolerance for the time interval between actions during the playback phase. During that time interval at playback, the system checks the recorded display data to the playback display data several times to determine if the playback display data is substantially similar to the recorded display data. A finding that the two are substantially similar indicates that a previous user action has completed and the system can progress to the next action in the execution scenario. This activity may be similar to the situation where the user is interacting with the application program and pauses periodically to view the display to

determine if the expected visible changes to the display have been made by the application program based on previous actions. If so, then a new action may be performed. If at the end of a higher bound of the time interval the application program has not produced an image on the display that the CCF system expected according to the execution scenario, then the CCF system may interrupt the playback of the execution scenario and generate an error report describing how the execution scenario has not been followed. In one embodiment, the scenario may be corrected and the CCF system may be required to use other branches to continue.

10       The cognitive control framework (CCF) system of embodiments of the present invention performs image analysis and object detection processing on display data from the GUI of the application program. The CCF system includes comparing an image captured during a recording phase (called IR) to the corresponding image captured during the playback phase (called IP). One task of the system is to detect an object in the IR to which the user applied an action, find the corresponding object in the IP, and continue progress on the execution path of the execution scenario by applying the action to the detected object. These steps may be repeated for multiple objects within an image, and may be repeated across multiple pairs of IRs and IPs over time. An object that the user has applied an action to may be called an "object of action." Absence in the IP of the object of action corresponding to the one found at IR means that one should capture the IP again at a later time and try to find the object of action again. Finally, either an object of action may be found in the IP or execution of the scenario may be halted and a report generated describing how the wrong state was achieved and the scenario may not be continued. In embodiments of the present invention, this detection of objects of action may be done in real time during the playback phase, progressing from one action to another. Thus, the image analysis process employed must have good performance so as to introduce only a minimal disturbance to the time conditions at playback.

The CCF system of embodiments of the present invention comprises an image analysis and detecting process. Such a process has at least two requirements. First, the process should be able to overcome some variations in the captured images such as different color scheme, fonts, and the layout and state of the visual elements. In one embodiment, comparison constraints for checking these items (color scheme, fonts, etc.) may be set to specified parameters in accordance with specific needs. Overcoming these variations is desirable because recording and playback might be executed in different operating environments such as different screen resolutions, different visual schemes, different window layouts, and so on. Additionally, there could be insignificant differences in corresponding IR (usually captured after an action was applied to an object of interest) and IP pairs (captured after a previous action was completed). Second, the implementation of the image analysis and object detection process should be fast enough to introduce only minimal disturbances and delay of application execution during playback.

By processing captured images, the system builds descriptions of the images in terms of the objects presented on them. Each display object may be represented by its contour and a plurality of properties. Table I enumerates some possible contour properties for use in the present invention. In other embodiments, other properties may also be used.

Property	Description
Location	Coordinates (on the image) of the contour center.
Image size	Characteristic contour size. In case of rectangular contours they are just vertical and horizontal sizes. For controls of more complicated shape, another format may be used.
Layout	Connection to other contours that lay in proximity to its boundaries/ layout pattern of this contour.
Content Type	Indicates what is inside of the contour: text, image or a combination.
Content	If the content type is text, then a text string; if image (e.g. icon), then the image.
Table 1. Contour properties	

Figure 2 is a flow diagram illustrating processing of a CCF system according to an embodiment of the present invention. During the recording phase 220 handled by recording component 102, at block 200 the system  
5 determines contours of objects in the IR. At block 202, the system detects a current object of activity. At block 204, the system detects additional objects adjacent to the current object of activity in the IR. These steps (200, 202, and 204) may be repeated over time for all objects of activity during execution of the application program in the recording phase.

10 Next, during the playback phase 222 handled by playback component 104, at block 206 the CCF system determines the contours of objects in the IP. At block 208, the CCF system filters contours by size to determine contours that may become hypotheses for active objects and contours that connect them. At block 210, the CCF system filters the  
15 objects by basic space layout in the IP to determine subsets of hypotheses for active and additional objects. For example, filtering criteria for space layout may include tables, wizards, and menus. In one embodiment, the user (or CCF schema with a cascade search) could set both strict (e.g. "as is") and fuzzy (e.g. "object could be near each other") conditions. At block  
20 212, the CCF system filters the objects by content to produce further subsets of hypotheses for active and additional objects. For example, the filtering criteria by content may include images and text. Moreover, in one embodiment, the user (or CCF schema with cascade search) could set both strict (e.g. "image should have difference in a few points and text should  
25 have minimal differences on a base of Levenstein distance") and fuzzy (e.g. "image could be stable to highlighting and have insignificant structural changes and text could have noticeable differences on a base of Levenstein distance without consideration of digits") conditions. At block  
30 214, the CCF system performs structural filtering of the objects to produce a best hypothesis for active objects.

Finally, at block 216, the CCF system recalculates old actions for a new object by applying the action according to the execution scenario. For example, suppose the user selected (via the mouse) the screen location at (X=70, Y=200), and that a button is displayed at the rectangle denoted (X1=50, Y1=150, X2=100, Y2=100). In the IP, the button may be represented as a rectangle denoted (X1=250, Y1=300, X2=200, Y2=100). For a general view, coordinates of the top left corner and the size of the rectangle may be changed. The mouse click (user selection) may be recalculated based on the position of the button and the scaled size (for X and Y coordinates). The calculation gives the new mouse click coordinates (e.g., X=290, Y=350).

Table II shows the input data and output of the image analysis process for Figure 2.

Table II. Image Analysis Processing

Step	Input Data	Result	Input parameters and Description
1. Contouring	Image from recoding (IR)	Contours	Thresholds, distances between objects (with some tolerance). Intel® OpenCV library used in one embodiment.
2. Detecting object of activity	Image IR and contours from previous step.	Contour representing object of activity	Typical object size (with tolerance) for object of action. Optical character recognition (OCR) and fuzzy text comparison, e.g. with Levenshtein distance.
3. Detecting additional objects around object of activity	Image IR, contours and active objects.	Additional objects and their layout against object of action	Typical object size (with tolerance) for additional objects. Structural analysis, e.g. "criss-cross" rules.
4. Contouring	Image from playback (IP)	Contours	Thresholds, distances between objects (with some tolerance). Intel® OpenCV library used in one embodiment.
5. Filtering by size	Contours from previous step	Contours that become hypotheses for active object and contours connected with them	Mean object size (with tolerance) based on active object characteristics evaluated at Step 2. Typical object size (with

			tolerance) for additional objects. Filtering out contours that don't fit into input size limits.
6. Filtering by basic space layout	Subsets of hypotheses for active and additional objects	Decreased subsets of hypotheses for active and additional objects	Fuzzy distance filtration. Fuzzy filtration for directions.
7. Filtering by content	Subsets of hypotheses for active and additional objects	Decreased subsets of hypotheses for active and additional objects	OCR and fuzzy text comparison, e.g. with Levenshtein distance. Fuzzy image comparison. Using "fuzzy content type" method for filtration.
8. Structural filtering	Subsets of hypotheses for active and additional objects	The best hypothesis for active objects.	Method based on fuzzy triple links both between objects from IR and their hypotheses from IP. It's stable to additional objects which don't have strong structural links with active object. Moreover, one can use the result of this method to choose the best hypotheses for active objects. Some other methods, e.g. Hough transformation may also be used

			here.
9. Recalculating old actions for new object	Object of action	Applied the action according to the execution scenario	Recalculating action coordinates in IP (playback image) coordinate system

During filtering at each step there is an evaluation of specific contour properties (as required for a specific filter). This filtering pipeline is  
5 designed in such a way that the most time consuming evaluation steps are shifted to later in the processing pipeline when the number of contours (hypotheses) is smaller. By using this approach, the overall computational cost may be decreased, thereby helping to ensure good performance of the system.

10 It is useful to maintain a compromise in order to make sure that the system does not filter out some contours in the early steps that may be later determined to be either a hypothesis of an object of activity or objects connected with an object of activity. In this regard, predefined input parameters may be set to broad limits that requires spending a little more  
15 time on processing of additional contours (hypotheses), but ensure that the system has not dropped important contours.

Example pseudo-code for one embodiment of the present invention is shown in Table III.

20 Table III. Pseudo Code Example

```
BEGIN CCF
<<<<<<< Recording >>>>>>>
LOOP /*recording, e.g. till a special key combination */
25   Wait on user action /*mouse, keyboard, it's possible to set something else*/
      Hook and save screenshot /*e.g. <Screenshot fileName="1.png"/>*/
      Save time interval from the previous action /*e.g. <Sleep
duration="2000"/>*/
30   Save information about user action
```

```

/*e.g. <Mouse action="RightClick" x="100" y="200"/>*/
END LOOP /*recording, e.g. till a special key combination*/
EXIT
<<<<<<< Post-processing >>>>>>>
5 Process saved data into a more compact form. It's possible for the user to
change it for his or her needs.
<<<<<<< Playback >>>>>>>
LOOP /*till the end of saved data*/
    Load time interval and wait in accordance with it.
10
    IF [actions depend on coordinates on the screen] /*e.g. mouse click*/
    THEN
        Load saved screenshot
        Detect object of action /*e.g. button*/, nearest structure-layout /*e.g.
15 menu items around button*/ and other useful info on saved screenshot
        TimeConditions_label: Hook the current screenshot
        Use image processing to find the corresponding object on the current
        screenshot /*it's possible to require more information from saved
        screenshot during search*/
20
        IF [Object not found] THEN
            IF [Check time condition] /*e.g. it's possible to repeat search 3 times
            with 1000-msec step, for example*/ THEN
                GOTO TimeConditions_label
25
            ELSE
                EXIT with error code /*moreover, it's possible to send
                corresponding report to log-file*/
                END IF
30
            ELSE
                Recalculate actions on a base of new found objects /*e.g.
                recalculate new coordinates for mouse click*/
                END IF
            END IF
35
        Produce actions /*it could be changed actions after image processing;
        moreover, it's possible to finish execution in case of wrong situations during
        actions*/
        END LOOP /*till the end of saved data*/
40
    EXIT
    END CCF

```

---

Embodiments of the present invention including image analysis and object of activity detection on two images may be illustrated by the following examples using a performance analyzer application program. These figures show applying the process blocks of Figure 2 to a first image from the recording phase (IR) and a corresponding image from the playback phase (IP). Figure 3 is an example display of the GUI of an application program captured and saved during a recording phase. This IR screen shot shows that the item "Tuning Activity" was selected by the user using a mouse. Figure 4 is an example display of the GUI of an application program captured during a playback phase. Note there are some insignificant changes in the displayed windows in comparison to Figure 3. Figure 5 is an example image illustrating objects identified during contouring operations of the recording phase according to an embodiment of the present invention as performed on the image of Figure 3. Figure 5 shows the sample output from block 200 of Figure 2. Figure 6 is an example image illustrating objects of activity of the recording phase according to an embodiment of the present invention as performed on the image of Figure 5. These contours were identified after performing blocks 202 and 204 of Figure 2 on the image from Figure 5. The contour with the text labeled "Tuning" has been determined in this example to be the current object of activity. Figure 7 is an example image illustrating objects identified during contouring operations of the playback phase according to an embodiment of the present invention. This image is output from performing block 206 of Figure 2 on the sample image of Figure 4. Finally, Figure 8 is an example image illustrating a hypothesis during the playback phase according to an embodiment of the present invention. Figure 8 shows hypotheses from Figure 7 for the "Tuning Activity" object of activity from Figure 6. Size, space, content, and structural filtration of blocks 206-214 has been performed. The ellipse represents the contour which was selected as the best hypothesis from performing block 216 of Figure 2. A new point for the

mouse click is recalculated relative to the given object (i.e., the "tuning" display object).

In some scenarios, filtration according to blocks 208 through 212 still result in many hypotheses to consider. The term hypothesis as used herein  
5 means a contour of an object on the playback image which corresponds to a contour of an object on the recorded image at a point in time. This means the previously applied filters didn't reject this correspondence of objects. When the number of hypotheses is large, more computational resources are needed. In one embodiment of the present invention, a methods for  
10 hypotheses filtration may be used to reduce the number of GUI hypotheses for objects in space (two dimensional (2D) for screen shots and multidimensional in the general case).

These methods comprise a search scheme that is simple yet powerful to select the right hypotheses despite the presence of several GUI  
15 noise conditions. In embodiments of the present invention, the noise conditions may comprise changeable color schemes, highlighting of items, noise from video devices, anti-aliasing, and other effects. GUI noise has two sources. The first source is the difference in GUI representation from run to run of the CCF system for a given application program. Between  
20 runs, for example there could be different positions of rows in a table, additional controls in a new product version, and so n. These differences result in changes in the playback images in comparison to the recorded images, as shown in the example images of Figures 15 and 16. The second source correlates with points of time when recorded and playback  
25 images are captured, especially if the user used a computer system's mouse for the user inputs to the application program under test. Briefly, when a recorded image is captured during a mouse action (such as clicking on the "New" item of Figure 9), it is correlated with a captured playback image representing the results of the previous user action (such as clicking  
30 on the "File" menu header in Figure 10). During the recording phase, the user moving the mouse from the "File" command to the "New" command

activates a highlighting operation that is captured. During the playback phase, the CCF system doesn't move the mouse from the "File" position in the previous step because the position of the "New" command is not yet known (and must still be determined). These things change the view of the playback image in comparison with the corresponding recorded image.

Similar noise conditions are evident in Figures 11 and 12. Movement of a mouse results in generation of animation of the "clam" icon in Figure 11. A similar situation is shown in Figures 13 and 14. Movement of the mouse generates the "Resource Perspective" tool tip during the recording phase on Figure 13. Movement of the mouse from the previous step on the playback phase generated a "VTune <sup>TM</sup> Performance Tools Perspective" tool tip to be displayed, and the CCF system captured this event in the playback image as shown in Figure 14.

In one embodiment of the present invention, the Cognitive Control Framework system reduces GUI noise after the recording phase for more effective play back. This embodiment correlates well with changes to the application program during product evolution. If an execution scenario is run several times, the CCF system will typically have problems with the search every time. One goal is to modify screen shots from the recording phase using new images from the playback phase and correct the scenario (e.g., point at new coordinates for mouse clicks). After this processing, the playback images will have fewer differences (GUI noise) than they had with initial screen shots from the recording phase. This allows users to select stronger conditions for playback, resulting in better performance and improved testing quality.

For clarity of presentation, let's consider specific real examples of GUI noise during the recording phase. Figure 9 is an example image illustrating a highlighted object in an image captured during the recording phase according to an embodiment of the present invention. The user clicked the "New" item in the "File" menu. Detailed behavior for a given activity could be the following (let's consider mouse activity, but the use of

hot keys is also possible). The user moved the mouse from the "File" menu header to the "New" item and clicked on the "New" item. Highlighting for selected item is visible on the captured recorded image. On the other hand, a screenshot which could be captured during the play back phase (as shown in Figure 10) will not show this highlighting because the CCF system task is searching for the corresponding item and the mouse will be situated at another position. This difference in images is a simple example of GUI noise after the recording phase.

The next example shows a more difficult GUI problem. Figure 11 is an example image illustrating an active object according to an embodiment of the present invention. Figure 11 presents an animated button which was pressed by mouse. Figure 12 is an example image illustrating an inactive object according to an embodiment of the present invention. Figure 12 shows the usual view of the button when it is not animated.

A similar noise situation is illustrated on Figure 13 and 14. Figure 13 is an example image illustrating a tool tip in a recorded image according to an embodiment of the present invention. Figure 14 is an example image illustrating a tool tip in a playback image according to an embodiment of the present invention. The recorded image shows a tool tip for a currently selected object but the playback image shows a tool tip for a previously pressed button.

Sometimes GUI changes during product evolution may be considered as a GUI noise. Figure 15 is an example image illustrating an index structure in a first version of a GUI according to an embodiment of the present invention. Figure 16 is an example image illustrating another index structure in a second version of a GUI according to an embodiment of the present invention. For example, Figure 16 shows an additional item "Quick Copy & Move ..." in dialog and new icons for a new product version, but the old "significant" item still exists there also. New objects could be considered in this situation as GUI noise in accordance with a previous recorded image

as shown in Figure 15. This situation could be considered as evolution of the product with requirements to adapt to the new changes.

In some situations there are more complex examples for GUI behavior and more significant differences between the recording phase and the playback phase screenshots. One possible way to solve these problems with a search of objects is to create a new complex algorithm, with a huge knowledge base. This is a very difficult task because the software marketplace continually produces new versions of application program having new controls and different GUI behavior. Embodiments of the present invention comprise a more effective way to solve this problem.

Usually, search conditions for the playback phase are rather strong, especially for scenarios and tests where one of the general aims is to check for a stable product state at the current time. In this situation, the recorded execution scenario couldn't be successfully run in noisy environment. It will encounter significant differences between the recorded and playback screenshots from the point of strong conditions. It's possible to set less strict limits for the search. However, this decreases the potential for verification of bugs and it has a very negative effect on using effectiveness of the present invention. If recorded screenshots correspond to the correct and the current images it allows conditions to be kept without changes. Thus, the general problem is how to obtain "clear" screenshots with the right data about activities for further use in CCF system processing.

Let us assume a stable application program or controlling the program's execution and the ability to indicate a valid run of the CCF system for it. The execution scenario could be recorded, "softer" conditions set for playback, and the execution scenario run again in a self registration mode with control for valid execution. This means that the system captures screenshots and tries to find objects with more adaptive rules for search. The CCF system then saves the screenshot and new information about objects (for example, new coordinates for mouse actions). The CCF system should be able to save additional information from the executed scenario

for its integrity. In other words, a new execution scenario should have updates for information correlated to screenshots (it could include coordinates, areas, images and text content, updated dynamical information, etc). Finally, visual information may be obtained which has  
 5 better correspondence with the real images during further playbacks. This allows the CCF system to return to "strict" conditions to control application programs for bug verification and other tasks.

Methods for GUI noise reduction could be complex, but this complexity is less than the corresponding complexity for investigation and  
 10 development of a search scheme in a GUI noise environment. Moreover, knowledge about an application program that is valid for execution could help to automate refreshing of the execution scenario through multiply runs in case of playback faults.

Embodiments of the present invention include methods which make  
 15 effective refreshing of the execution scenarios. In other embodiments, additional methods may be used to improve GUI noise reduction that leads to easy portability and updates for scenarios between different operating systems and versions during product evolutions. An embodiment of the present invention includes a hierarchy of methods (e.g., algorithms,  
 20 schemas, "strict" conditions, etc.) as shown below.

1. At first, use "strict" methods. The playback images typically don't have significant differences with the recording images, so it makes sense to use narrow bounds for each parameter, e.g., size of  
 25 contours, text content, layout, etc.
2. Use stable to highlighting methods because this is the usual situation for GUI dialogs, menus, etc. The simplest change which could take place is highlighting, and a method which is stable may be used for handling highlighting.
- 30 3. Use environment information because this data usually has less noise than a searched active object. The simplest example of this is

animation: an active object on the playback image (such as in Figure 12) is different from one on the recording image (such as in Figure 11); additional objects are similar.

- 5      4. Use text information because action changes could be only in the fonts used. A simple change which could take place is another text font and a method may be used which is stable for handling font changes.
- 10     5. Use additional delays during tests execution (but save old test runs) because this helps avoid trouble with early "soft" searching. An additional load on the operating system could affect execution time for the application program, so it's possible to use delays when capturing the screenshot and search objects during playback to promote obtaining a good result.
- 15     6. Use a complex search and the best hypothesis chosen through corresponding methods, e.g., "fuzzy" ones. Sometimes the application program could provide a different view on every run, so the user could provide his or her own complex methods to find active objects. For example, an iterative search procedure may be used.
- 20     7. Divide the execution scenario into modules because this helps refresh and tune the execution scenario over multiple runs. Some steps (row of steps) could be replayed with one type of search parameters and others with different search conditions; it's easier to split a task into sub-tasks and solve them individually.
- 25     8. Use "as is" play back scheme and/or manual updating for screenshots and recorded information in very difficult situations. Manual correction for the scenario could help, and the playback may be processed with "point-to-point" conditions (e.g., manually select the same point with the mouse during playback as it took place during the recording phase).

30

In at least one embodiment of the present invention, at a first stage of processing, the recorded image and the execution scenario are obtained for every step of operation of the application program under test. Next, "soft" search conditions may be set. Soft search conditions include a first set of bounds for differences in shapes of contours, text and image content, layout, etc. Then, the execution may be played back automatically using the CCF system. Figure 18 is an example image illustrating a recorded image according to an embodiment of the present invention. It is a result of a valid execution and soft conditions being applied. For every step of the operation of the application program, a new playback image may be generated. Soft search conditions allow the CCF system to attempt to find the right active object in spite of GUI noise. The recorded and newly generated playback images are saved again and the execution scenario may be modified with new coordinates for mouse (or other user input) activity. Typically, this is the only change done to update an execution scenario. Figure 19 is an example image illustrating a playback image according to an embodiment of the present invention. In this example, Figure 19 does not quite match Figure 18.

At a second stage of processing, the search conditions may be set to "stronger" or "stricter" search conditions for applying the execution scenario to verify execution of the application program. Strict search conditions include a second set of bounds for differences in shapes of contours, text and image content, layout, etc. The first set of bounds of differences is different than the second set of bounds of differences. At this time, the recorded images are screenshots obtained from playback processing using "soft" search conditions as in Figure 19. Thus, Figure 20 is an example image illustrating another recorded image according to an embodiment of the present invention. This recorded image was copied from the previously generated playback image. For every step of the execution scenario, a new playback image may be generated during playback, such as is shown in Figure 21. This playback image, in the case of the right workflow of the

application program, is similar to the recorded image of Figure 20. This processing allows the CCF system to better adapt to any inconsistencies in the application program.

Figure 22 is a flow diagram illustrating GUI noise reduction processing according to an embodiment of the present invention. At block 300, the execution scenario may be recorded. At block 302, soft search conditions may be set for the application program for the same execution scenario. At block 304, the application program may be played back under the control of the CCF system according to the execution scenario with soft conditions for the search. During playback the execution scenario may be updated, including saving new recorded images (taken from generated playback images) and coordinates for user inputs such as mouse selections. At block 306, stronger conditions for the search may then be set for use in subsequent playbacks. At block 308, the application program may be played back again under the control of the CCF system according to the updated execution scenario with stronger search conditions. This process may be repeated until a satisfactory result is achieved. An active object should be found because the application program is known to work correctly during a given playback and the object should exist.

An advantage of embodiments of the present invention is that it is applicable to any application program exposing a visual interface on any platform and operating system, and is not dependent on a specific API, or architecture of visual system implementation (like Win32 or X-Windows API), or specific operating system. It correlates with an advantage of the overall Cognitive Control Framework approach, which works across platforms. All other known systems are dependent to a small or large extent on system APIs while working with visual elements. A further advantage of this approach is that it is an easy way to clear screen shots from unnecessary user activity effects. It further decreases the problems during playback. Another advantage is that it is an easy way to help with automatic portability of old scenarios to new versions of products. It

decreases the time needed to support a baseline of scenarios for application program testing. Another advantage is that it is a scalable way for using new algorithms for solving the execution scenario refresh task.

Reference in the specification to "one embodiment" or "an  
5 embodiment" of the present invention means that a particular feature, structure or characteristic described in connection with the embodiment is included in at least one embodiment of the present invention. Thus, the appearances of the phrase "in one embodiment" appearing in various places throughout the specification are not necessarily all referring to the  
10 same embodiment.

Although the operations detailed herein may be described as a sequential process, some of the operations may in fact be performed in parallel or concurrently. In addition, in some embodiments the order of the operations may be rearranged without departing from the scope of the  
15 invention.

The techniques described herein are not limited to any particular hardware or software configuration; they may find applicability in any computing or processing environment. The techniques may be implemented in hardware, software, or a combination of the two. The  
20 techniques may be implemented in programs executing on programmable machines such as mobile or stationary computers, personal digital assistants, set top boxes, cellular telephones and pagers, and other electronic devices, that each include a processor, a storage medium readable by the processor (including volatile and non-volatile memory  
25 and/or storage elements), at least one input device, and one or more output devices. Program code is applied to the data entered using the input device to perform the functions described and to generate output information. The output information may be applied to one or more output devices. One of ordinary skill in the art may appreciate that the invention  
30 can be practiced with various computer system configurations, including multiprocessor systems, minicomputers, mainframe computers, and the

like. The invention can also be practiced in distributed computing environments where tasks may be performed by remote processing devices that are linked through a communications network.

Each program may be implemented in a high level procedural or  
5 object oriented programming language to communicate with a processing system. However, programs may be implemented in assembly or machine language, if desired. In any case, the language may be compiled or interpreted.

Program instructions may be used to cause a general-purpose or  
10 special-purpose processing system that is programmed with the instructions to perform the operations described herein. Alternatively, the operations may be performed by specific hardware components that contain hardwired logic for performing the operations, or by any combination of programmed computer components and custom hardware components. The methods  
15 described herein may be provided as a computer program product that may include a machine accessible medium having stored thereon instructions that may be used to program a processing system or other electronic device to perform the methods. The term "machine accessible medium" used herein shall include any medium that is capable of storing or encoding  
20 a sequence of instructions for execution by a machine and that cause the machine to perform any one of the methods described herein. The term "machine accessible medium" shall accordingly include, but not be limited to, solid-state memories, and optical and magnetic disks. Furthermore, it is common in the art to speak of software, in one form or another (e.g.,  
25 program, procedure, process, application, module, logic, and so on) as taking an action or causing a result. Such expressions are merely a shorthand way of stating the execution of the software by a processing system cause the processor to perform an action of produce a result.

P22614

## 1 CLAIMS

2

3 What is claimed is:

4

5 1. A computer-implemented method of reducing graphical user  
6 interface (GUI) noise comprising:7 recording a first execution scenario for control of operation of an  
8 application program having a GUI during a recording phase of operation of a  
9 cognitive control framework system;10 setting soft conditions for a search for the application program for the first  
11 execution scenario;12 playing back the application program according to the first execution  
13 scenario during a playback phase of operation of the cognitive control framework  
14 system;15 updating the first execution scenario to form a second execution scenario  
16 to reduce GUI noise conditions observed during playback, including updating  
17 recorded images originally generated by the GUI during the recording phase and  
18 updating coordinates for user input data;19 setting stronger conditions for the search for use in subsequent  
20 playbacks; and21 playing back the application program according to the second execution  
22 scenario with the stronger conditions for search.

23

24 2. The method of claim 1, wherein the soft conditions comprise a first set  
25 of bounds for differences in shapes of contours, text and image content, or  
26 layout.

27

28 3. The method of claim 2, where the stronger conditions comprise a  
29 second set of bounds for differences in shapes of contours, text and image  
30 content, or layout, the second set being different than the first set.

31

P22614

32           4. The method of claim 1, wherein the user input data comprises mouse  
33 selections.

34

35           5. The method of claim 1, wherein GUI noise conditions comprise at least  
36 one of changeable color schemes, highlighting of items, noise from video  
37 sources, and anti-aliasing effects.

38

39           6. The method of claim 1, wherein updating recorded images comprises  
40 using playback images as recorded images for subsequent playbacks.

41

42           7. An article comprising: a machine accessible medium containing  
43 instructions, which when executed, result in reducing graphical user interface  
44 (GUI) noise by

45           recording a first execution scenario for control of operation of an  
46 application program having a GUI during a recording phase of operation of a  
47 cognitive control framework system;

48           setting soft conditions for a search for the application program for the first  
49 execution scenario;

50           playing back the application program according to the first execution  
51 scenario during a playback phase of operation of the cognitive control framework  
52 system;

53           updating the first execution scenario to form a second execution scenario  
54 to reduce GUI noise conditions observed during playback, including updating  
55 recorded images originally generated by the GUI during the recording phase and  
56 updating coordinates for user input data;

57           setting stronger conditions for the search for use in subsequent  
58 playbacks; and

59           playing back the application program according to the second execution  
60 scenario with the stronger conditions for search.

61

P22614

62           8. The article of claim 7, wherein the soft conditions comprise a first set of  
63 bounds for differences in shapes of contours, text and image content, or layout.

64  
65           9. The article of claim 8, where the stronger conditions comprise second  
66 set of bounds for differences in shapes of contours, text and image content, or  
67 layout, the second set being different than the first set.

68  
69           10. The article of claim 7, wherein the user input data comprises mouse  
70 selections.

71  
72           11. The article of claim 7, wherein GUI noise conditions comprise at least  
73 one of changeable color schemes, highlighting of items, noise from video  
74 sources, and anti-aliasing effects.

75  
76           12. The article of claim 7, wherein instructions to update recorded images  
77 comprise instructions to use playback images as recorded images for  
78 subsequent playbacks.

79  
80           13. A method of automatically controlling execution of an application  
81 program having a GUI to reduce GUI noise comprising:  
82           capturing user input data and images displayed by the GUI during a  
83 recording phase of execution of the application program;  
84           analyzing the captured user input data and recorded images to generate a  
85 first execution scenario during the recording phase;  
86           setting soft conditions for a search for the application program for the first  
87 execution scenario;  
88           generating simulated user input data based on the first execution scenario  
89 during a playback phase of execution of the application program and inputting  
90 the simulated user input data to the application program;

P22614

91 performing image analysis on playback images displayed by the GUI as a  
92 result of processing the simulated user input data during the playback phase and  
93 the recorded images;

94 updating the first execution scenario to form a second execution scenario  
95 to reduce GUI noise conditions observed during playback, including updating the  
96 recorded images originally generated by the GUI during the recording phase and  
97 updating coordinates for user input data;

98 setting stronger conditions for the search for use in subsequent  
99 playbacks; and

100 playing back the application program according to the second execution  
101 scenario with the stronger conditions for search.

102

103 14. The method of claim 13, wherein the soft conditions comprise a first  
104 set of bounds for differences in shapes of contours, text and image content, or  
105 layout.

106

107 15. The method of claim 14, where the stronger conditions comprise a  
108 second set of bounds for differences in shapes of contours, text and image  
109 content, or layout, the second set being different than the first set.

110

111 16. The method of claim 14, wherein GUI noise conditions comprise at  
112 least one of changeable color schemes, highlighting of items, noise from video  
113 sources, and anti-aliasing effects.

114

115 17. The method of claim 14, wherein updating recorded images  
116 comprises using playback images as recorded images for subsequent  
117 playbacks.

118

119 18. An article comprising: a machine accessible medium containing  
120 instructions, which when executed, result in automatically controlling execution of  
121 an application program having a GUI to reduce GUI noise by

P22614

122 capturing user input data and images displayed by the GUI during a  
123 recording phase of execution of the application program;  
124 analyzing the captured user input data and recorded images to generate a  
125 first execution scenario during the recording phase;  
126 setting soft conditions for a search for the application program for the first  
127 execution scenario;  
128 generating simulated user input data based on the first execution scenario  
129 during a playback phase of execution of the application program and inputting  
130 the simulated user input data to the application program;  
131 performing image analysis on playback images displayed by the GUI as a  
132 result of processing the simulated user input data during the playback phase and  
133 the recorded images;  
134 updating the first execution scenario to form a second execution scenario  
135 to reduce GUI noise conditions observed during playback, including updating the  
136 recorded images originally generated by the GUI during the recording phase and  
137 updating coordinates for user input data;  
138 setting stronger conditions for the search for use in subsequent  
139 playbacks; and  
140 playing back the application program according to the second execution  
141 scenario with the stronger conditions for search.

142  
143 19. The article of claim 18, wherein the soft conditions comprise a first set  
144 of bounds for differences in shapes of contours, text and image content, or  
145 layout.

146  
147 20. The article of claim 19, where the stronger conditions comprise a  
148 second set of bounds for differences in shapes of contours, text and image  
149 content, or layout, the second set being different than the first set.

150

P22614

151           21. The article of claim 18, wherein GUI noise conditions comprise at  
152 least one of changeable color schemes, highlighting of items, noise from video  
153 sources, and anti-aliasing effects.

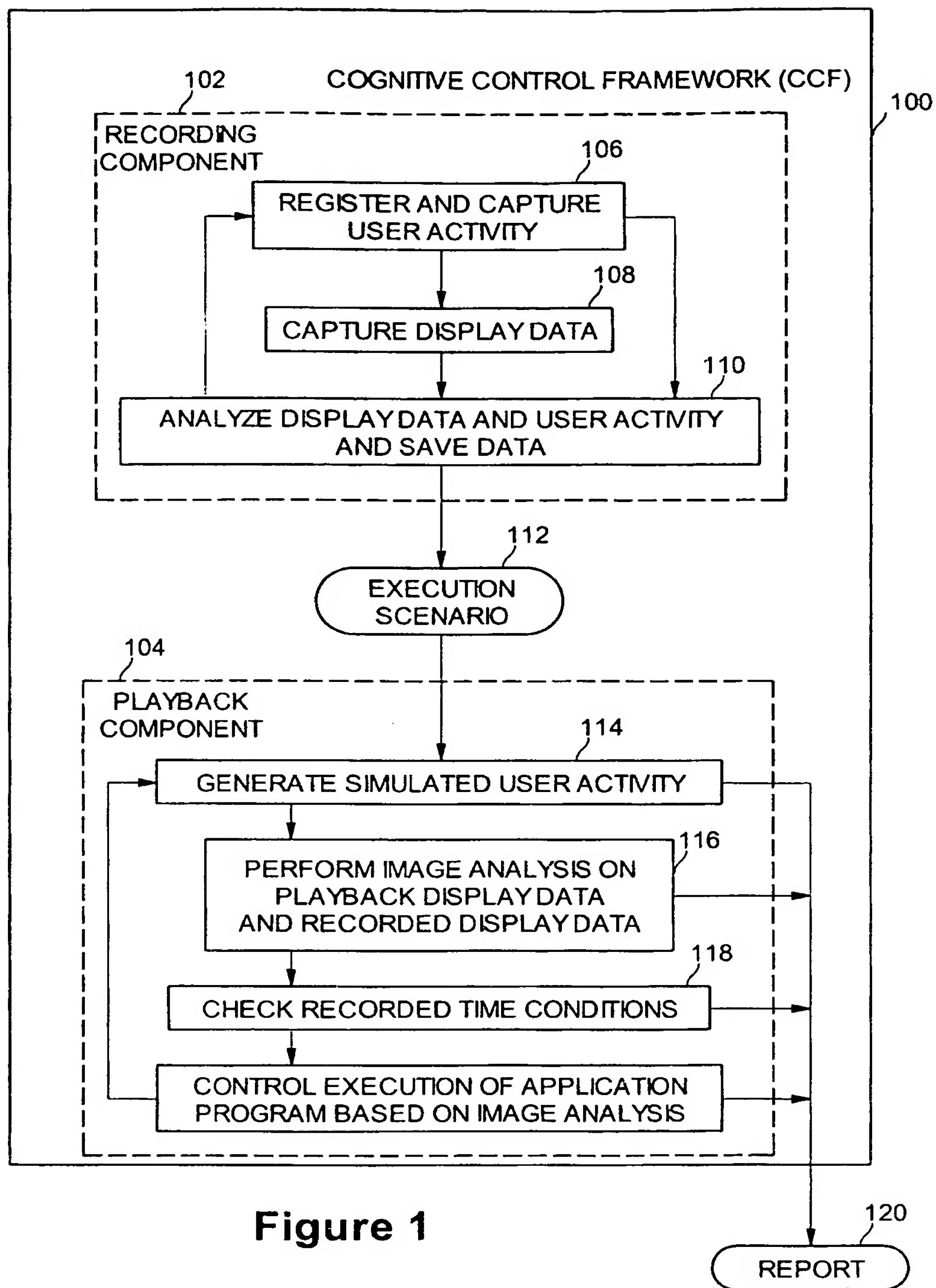
154

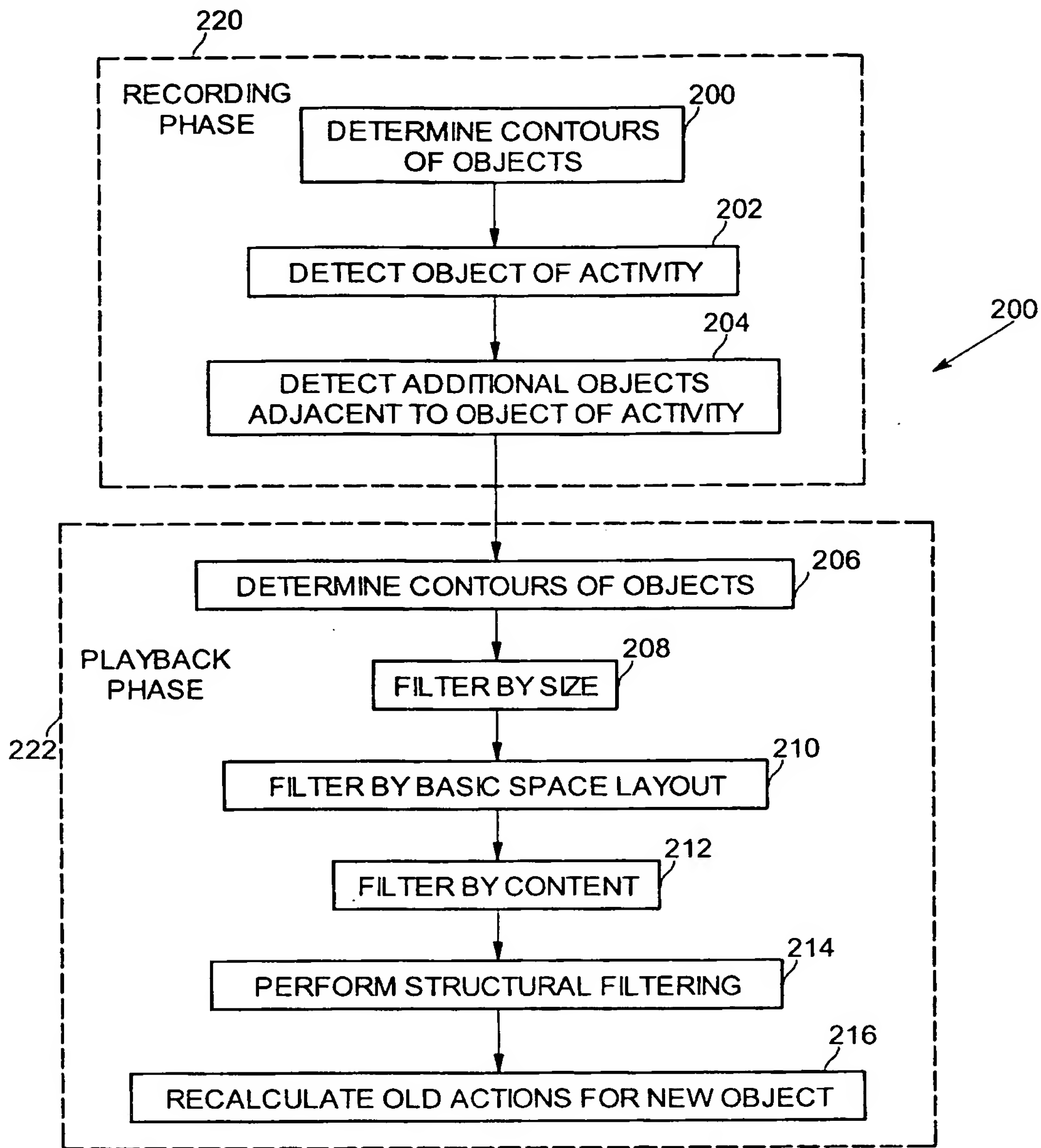
155           22. The article of claim 18, wherein instructions to update recorded  
156 images comprise instructions to use playback images as recorded images for  
157 subsequent playbacks.

158

## ABSTRACT OF THE DISCLOSURE

Reducing graphical user interface (GUI) noise maybe achieved by recording a first execution scenario for control of operation of an application program having a GUI during a recording phase of operation of a cognitive control framework system, setting soft conditions for a search for the application program for the first execution scenario, playing back the application program according to the first execution scenario during a playback phase of operation of the cognitive control framework system, updating the first execution scenario to form a second execution scenario to reduce GUI noise conditions observed during playback, including updating recorded images originally generated by the GUI during the recording phase and updating coordinates for user input data, setting stronger conditions for the search for use in subsequent playbacks; and playing back the application program according to the second execution scenario with the stronger conditions for search.

**Figure 1**



**Figure 2**

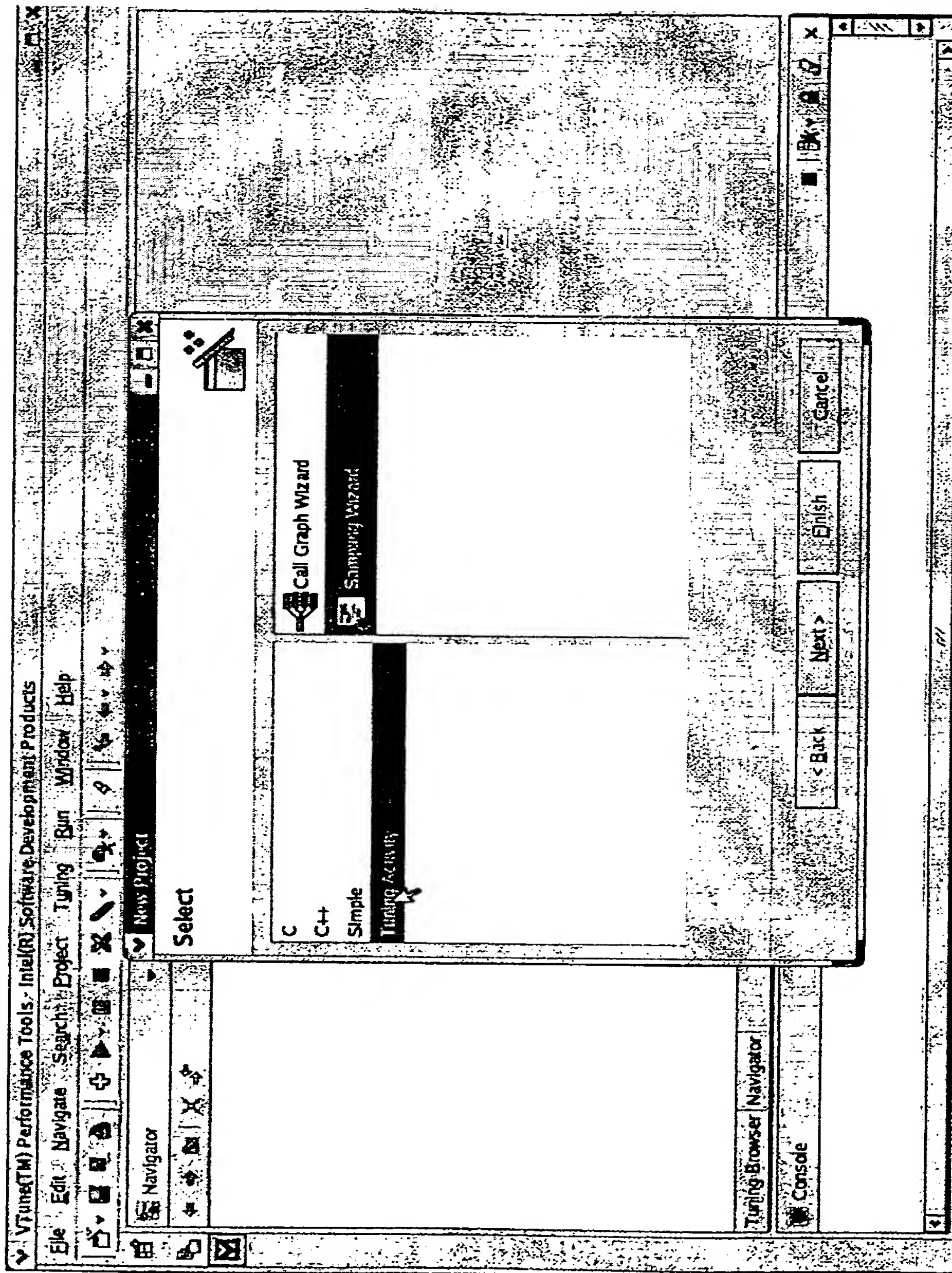


Figure 3

4/15

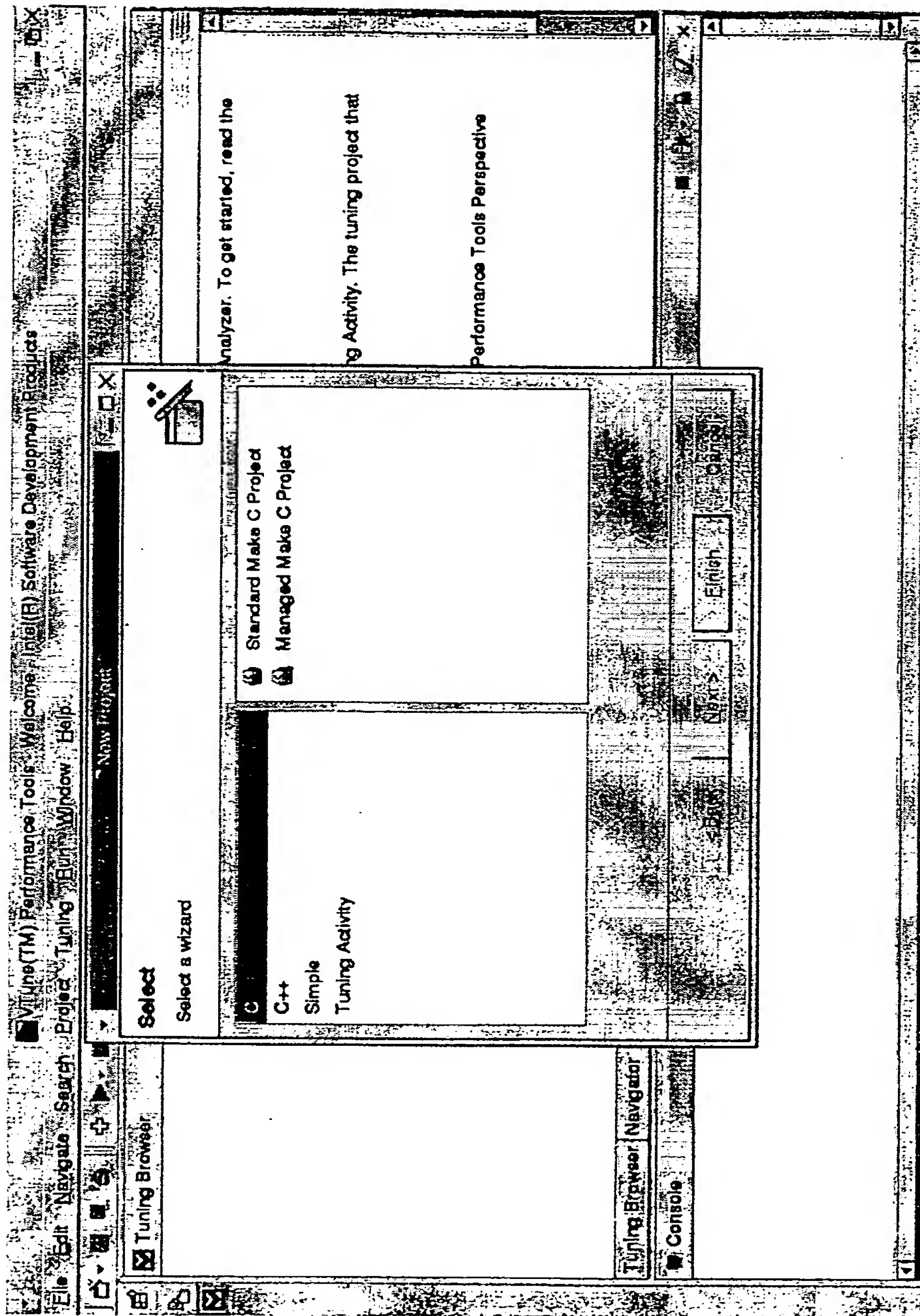
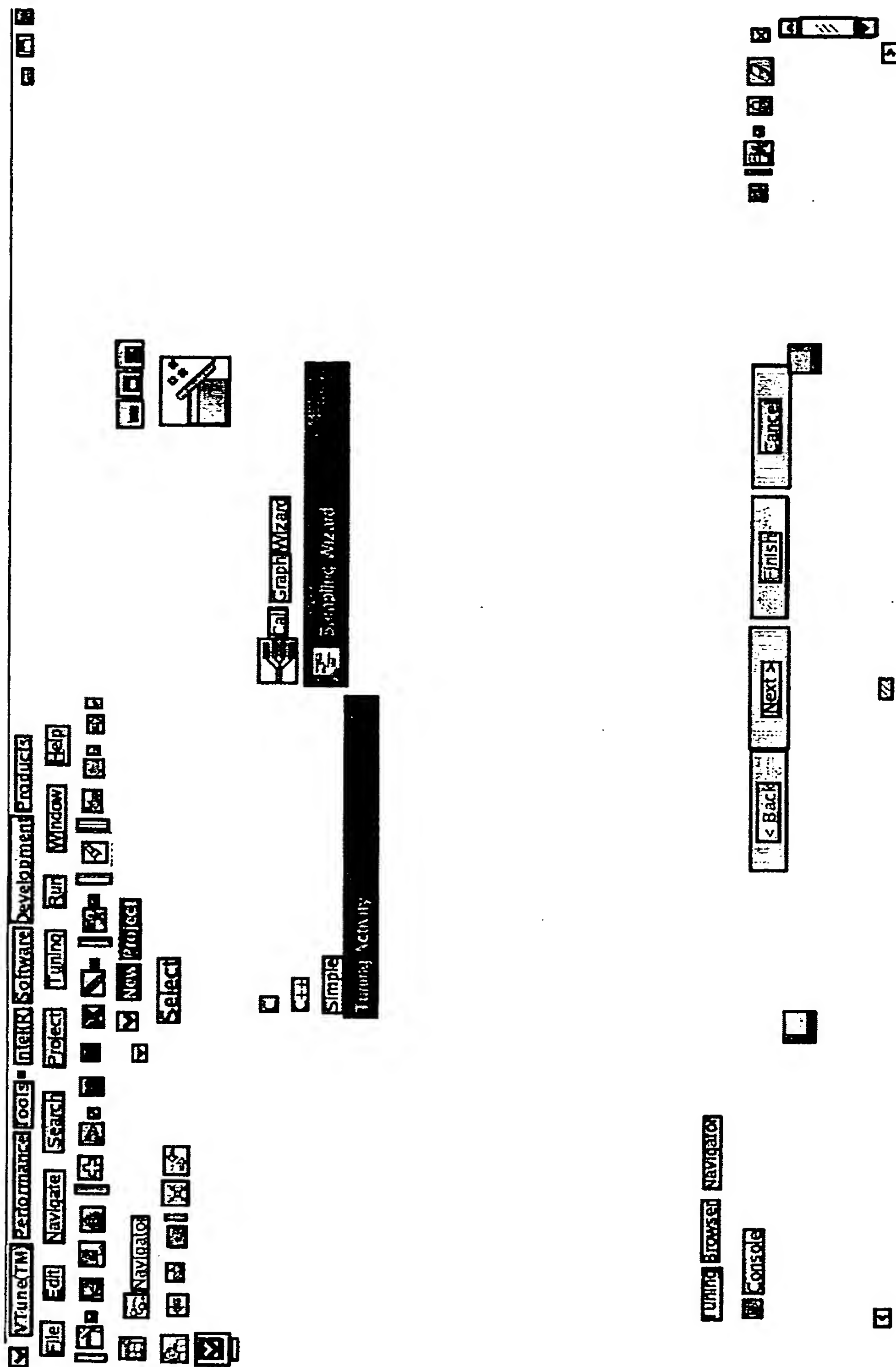


Figure 4



## Figure 5

6/15



Figure 6

7/15

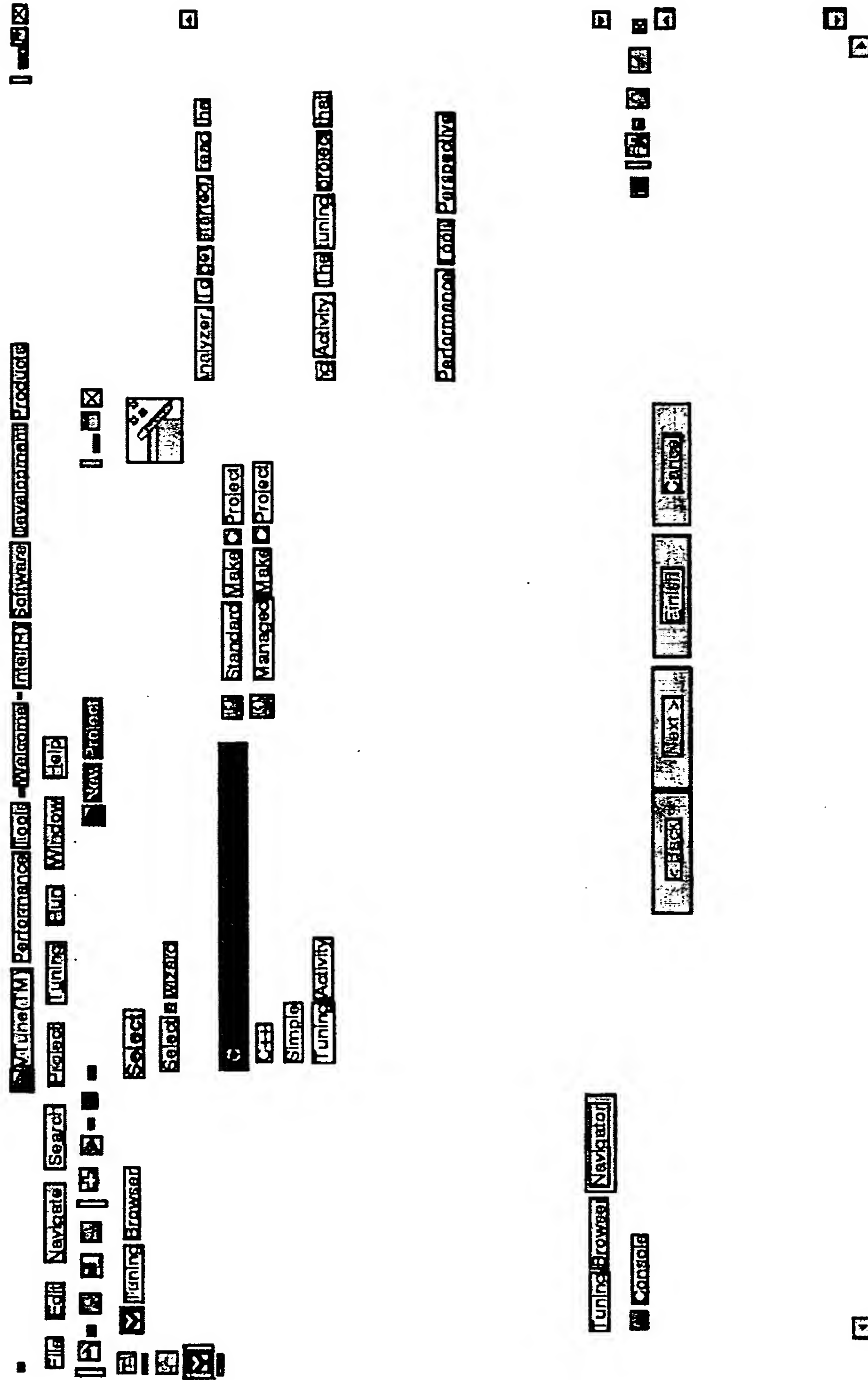


Figure 7

8/15

Tuning

Figure 8

Tuning

Tuning

Tuning

Tuning

9/15

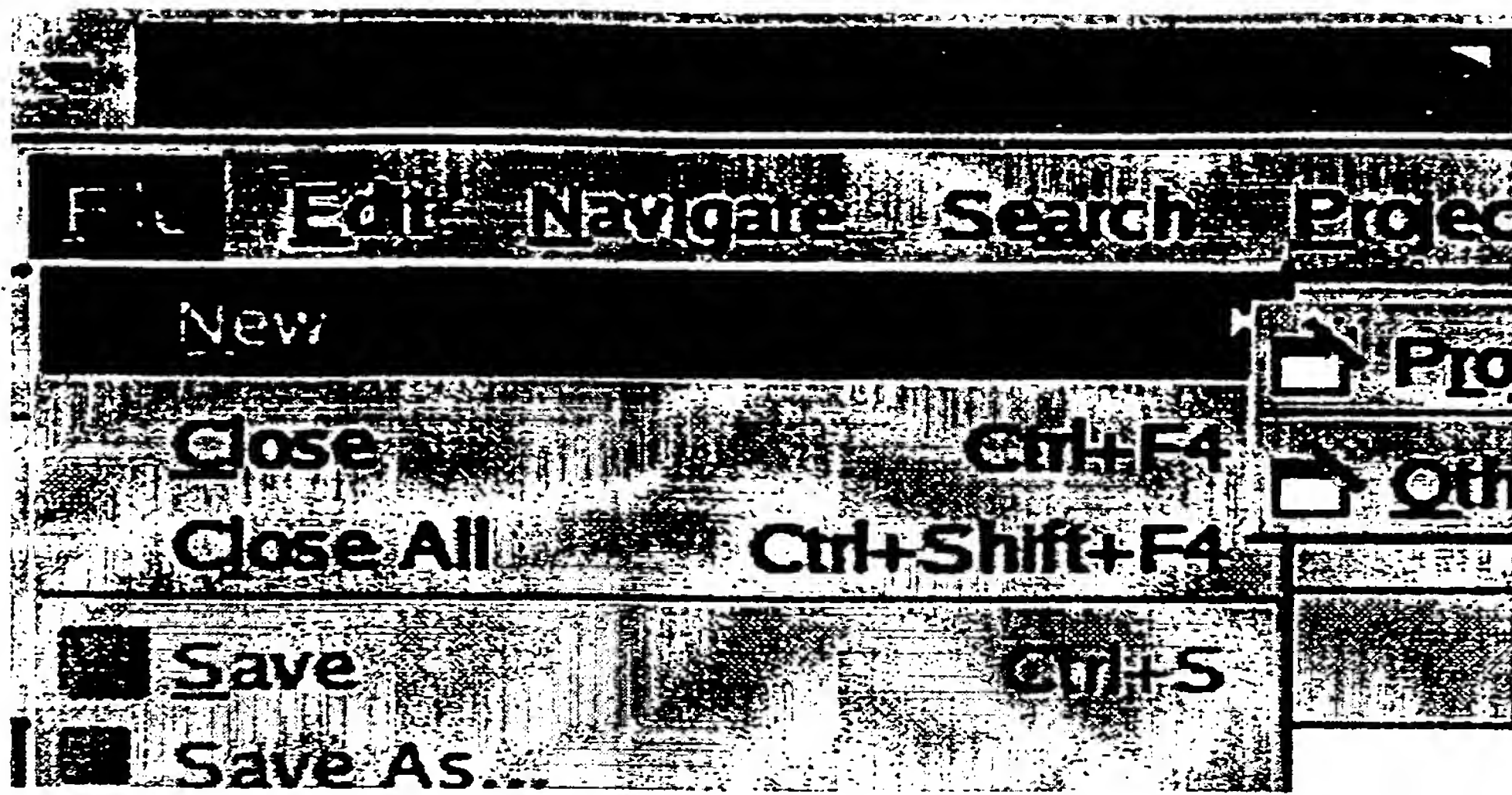


Figure 9

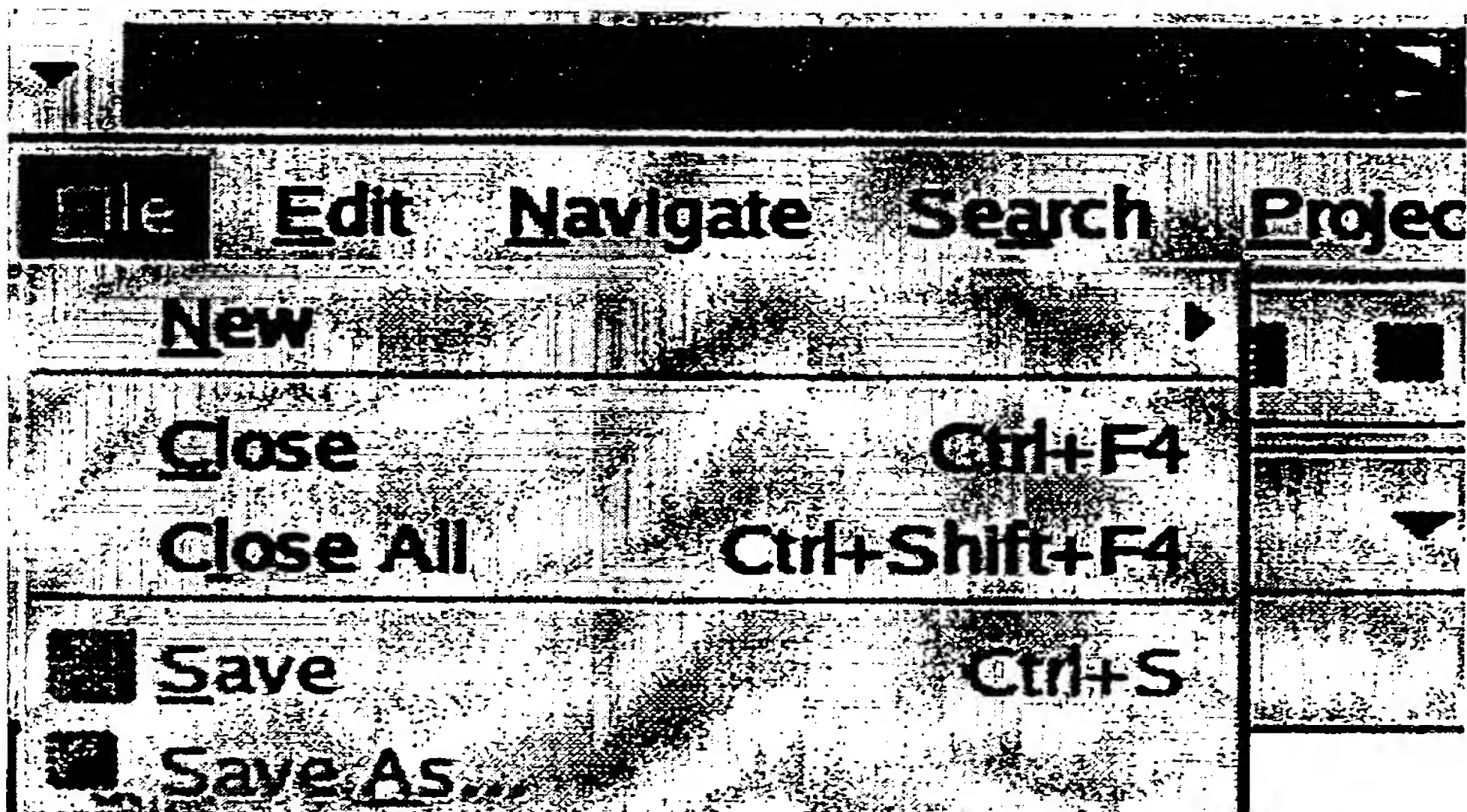


Figure 10

10/15

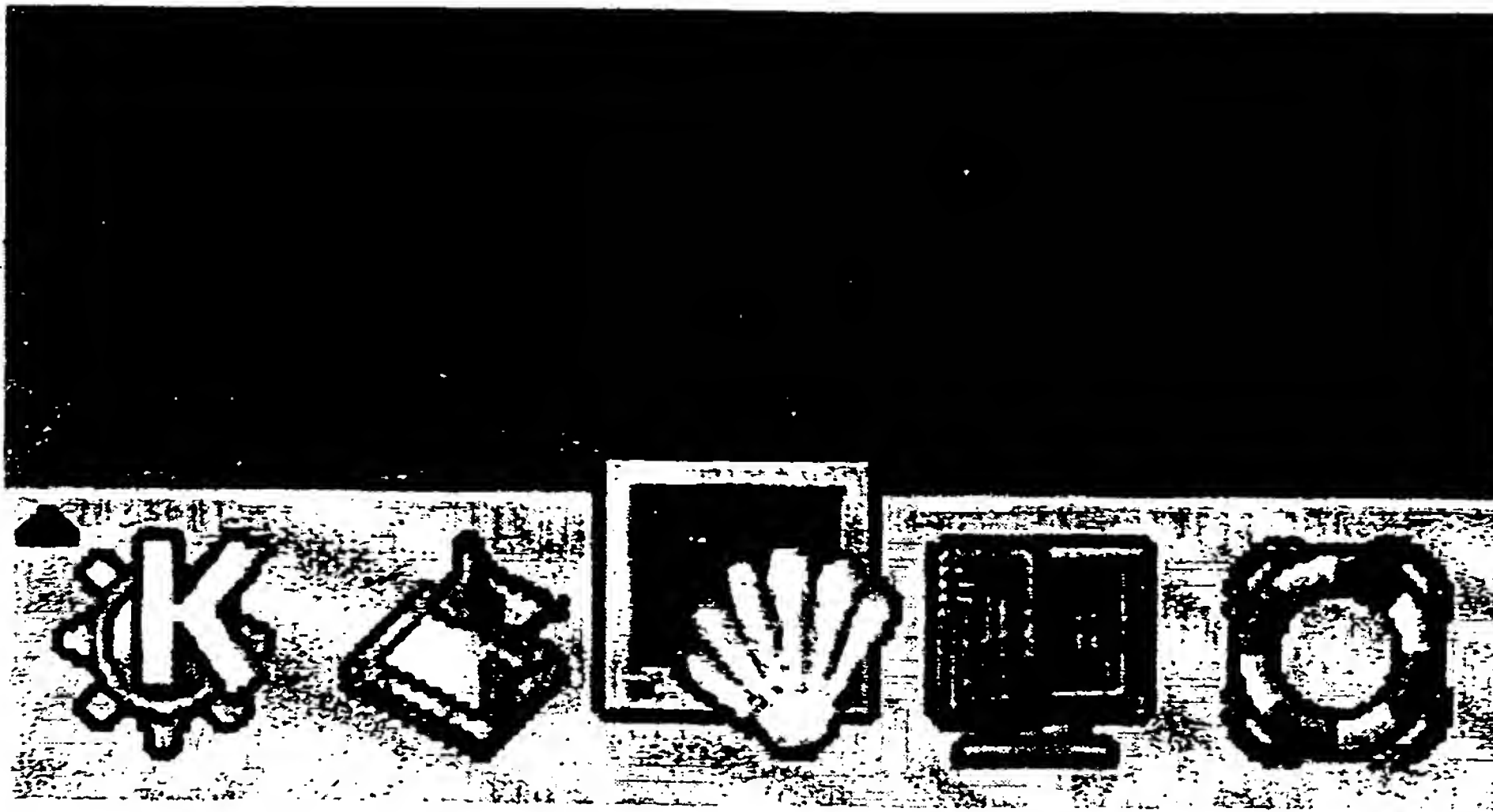


Figure 11

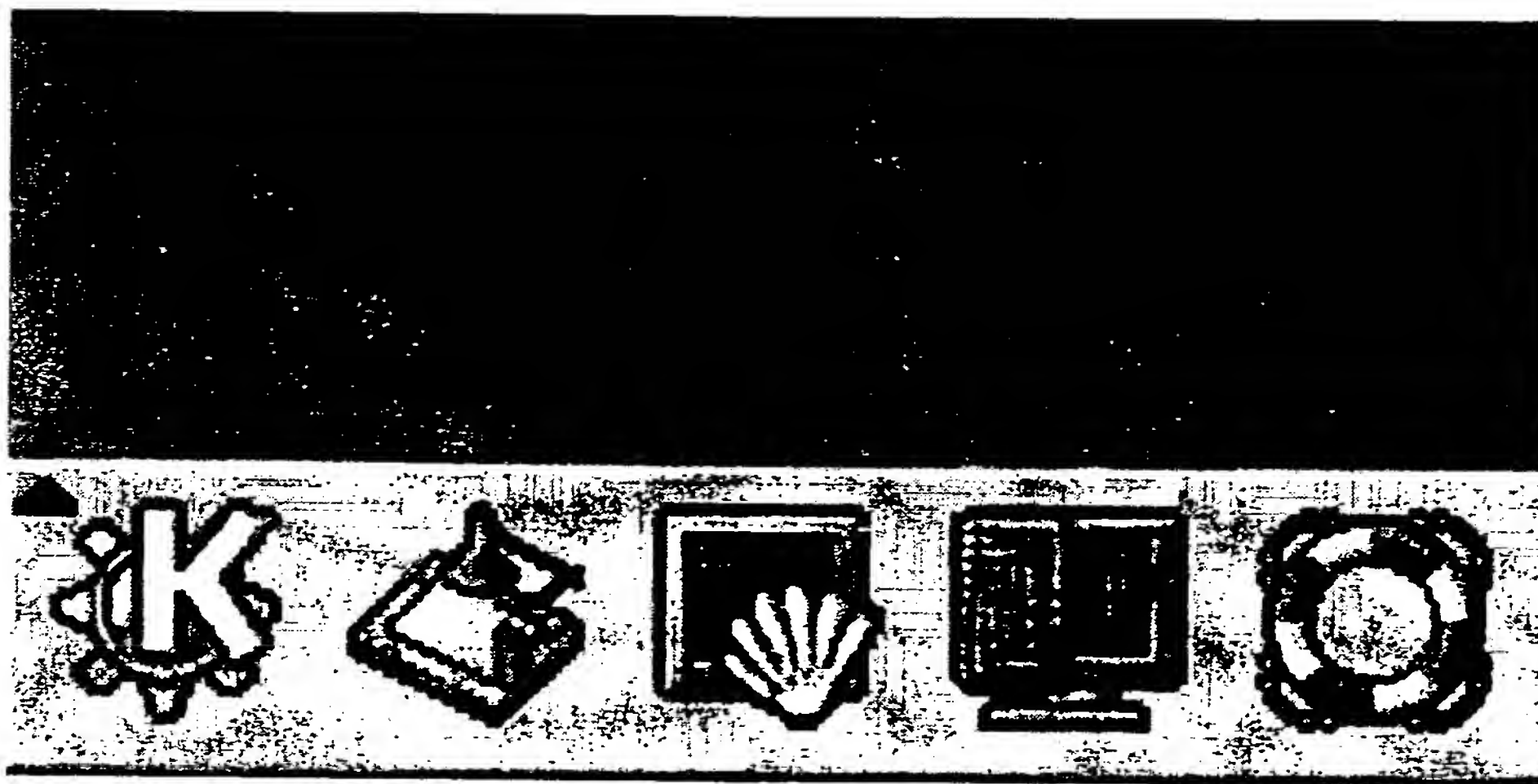


Figure 12

11/15

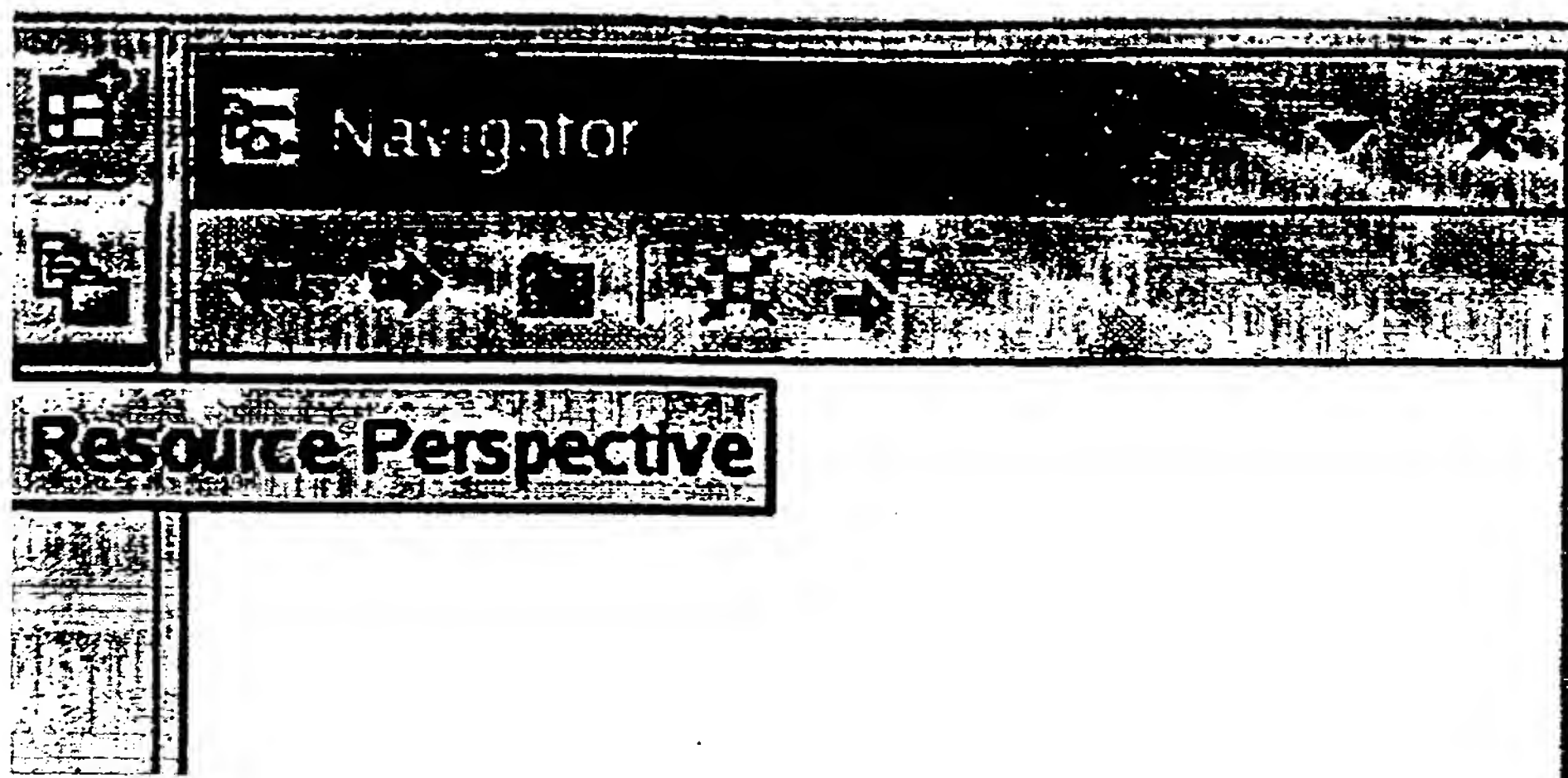


Figure 13

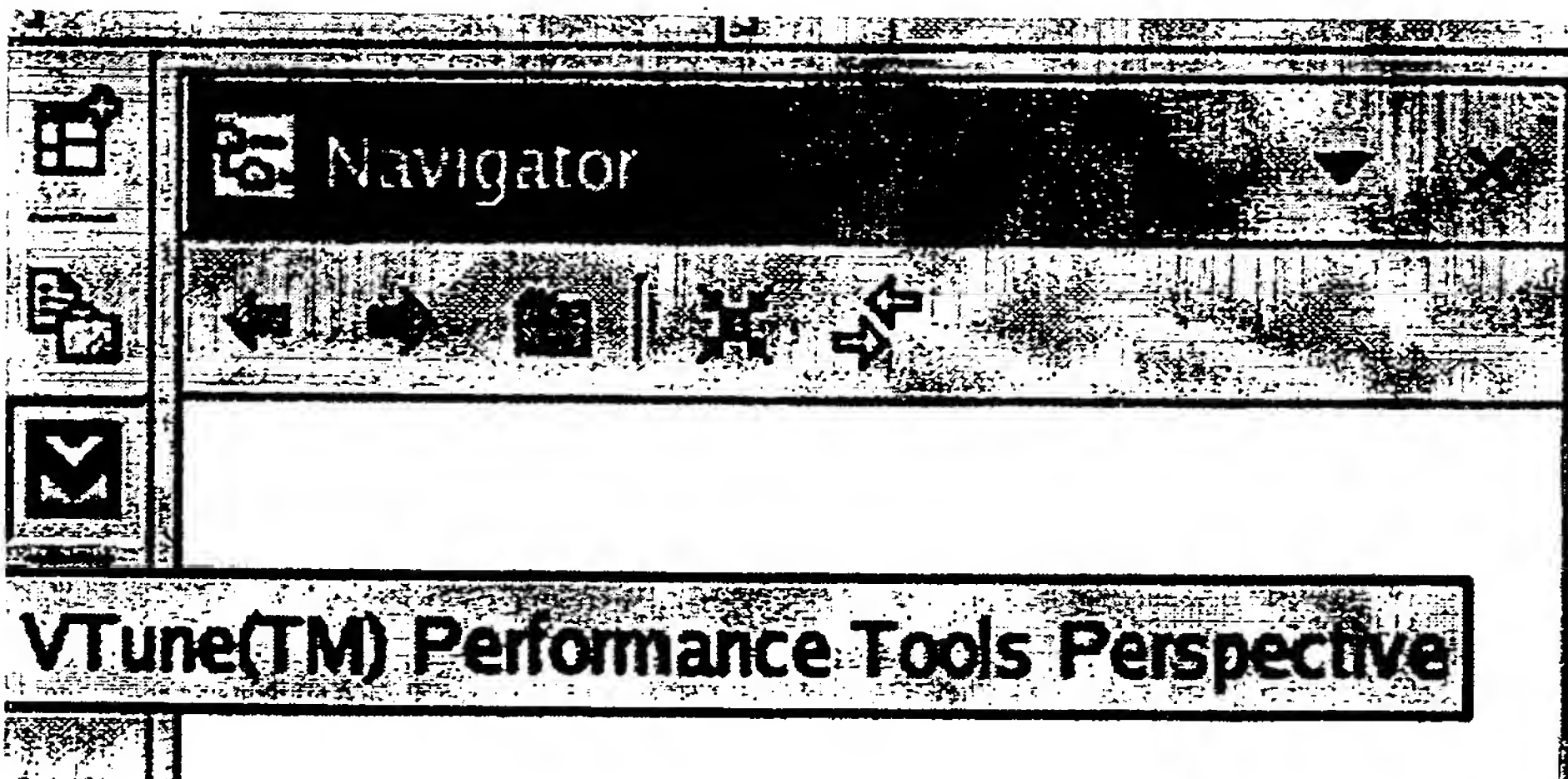


Figure 14

12/15

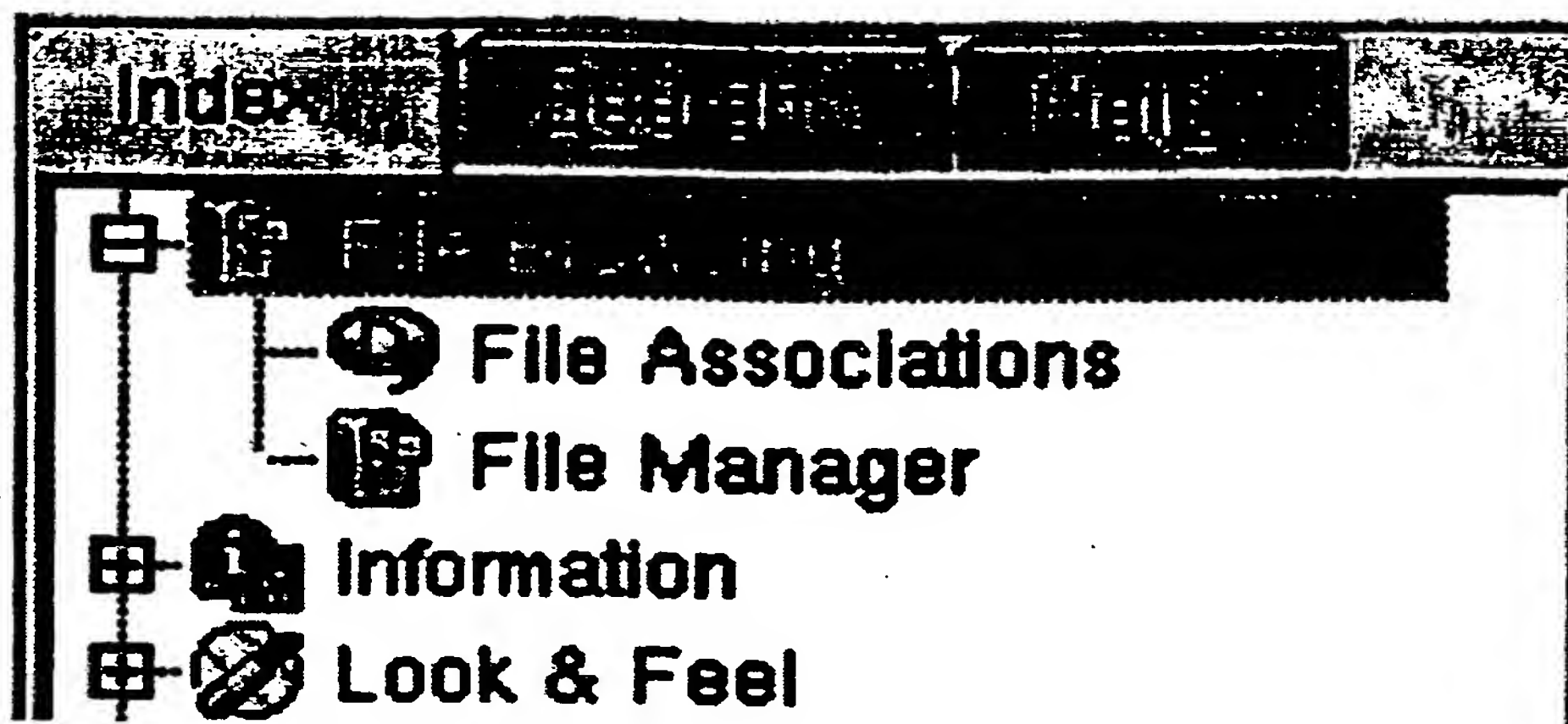


Figure 15

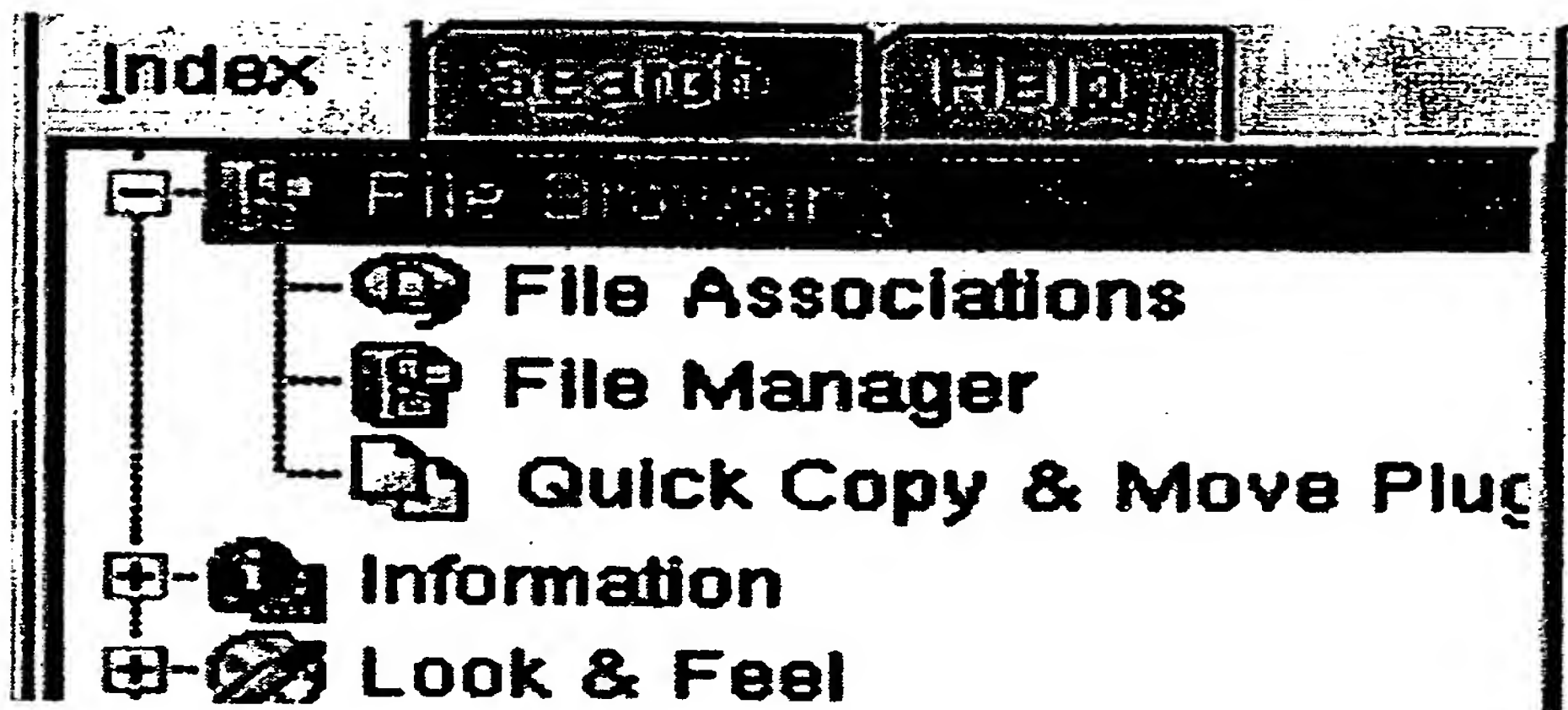


Figure 16

13/15

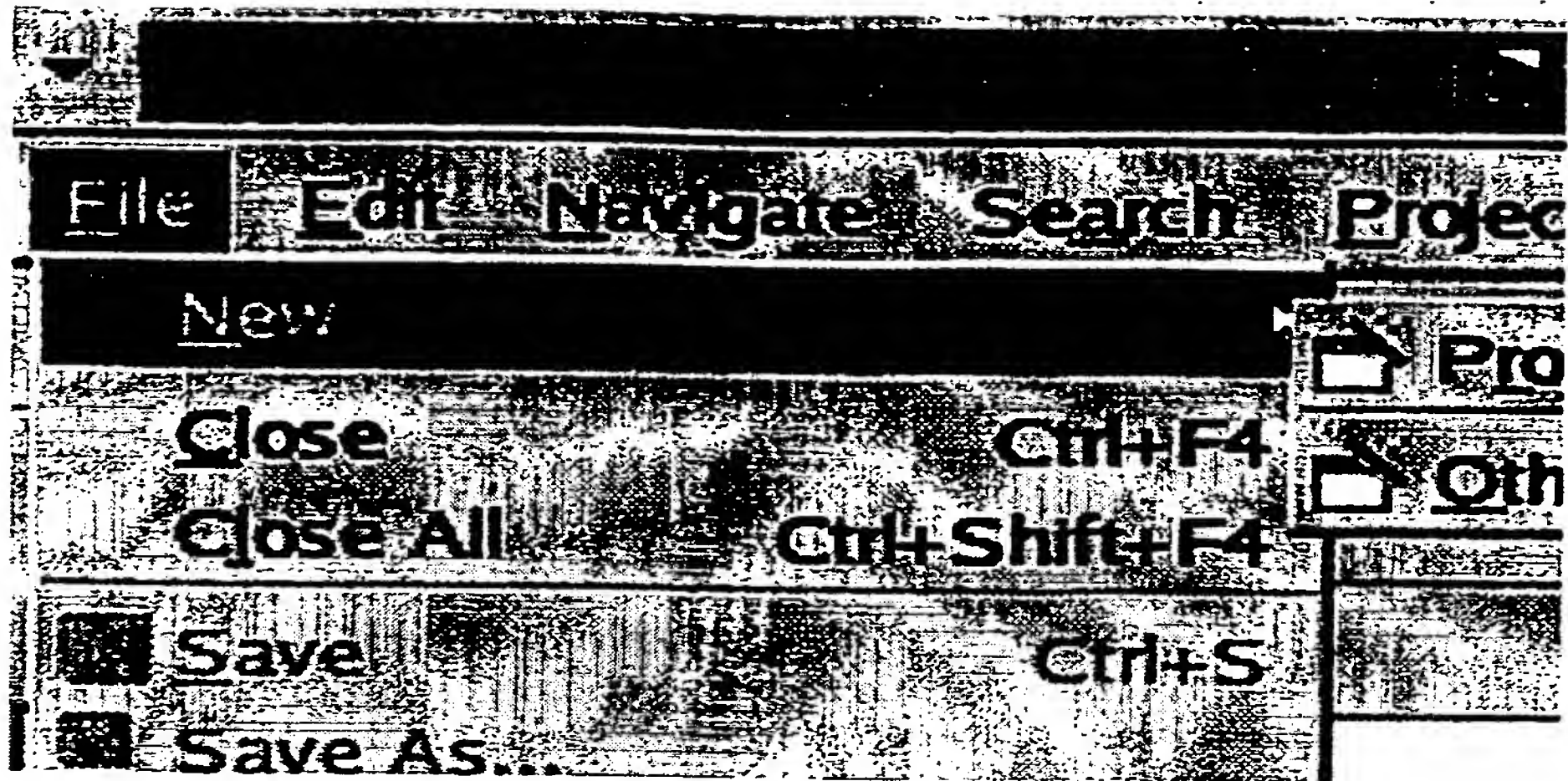


Figure 17

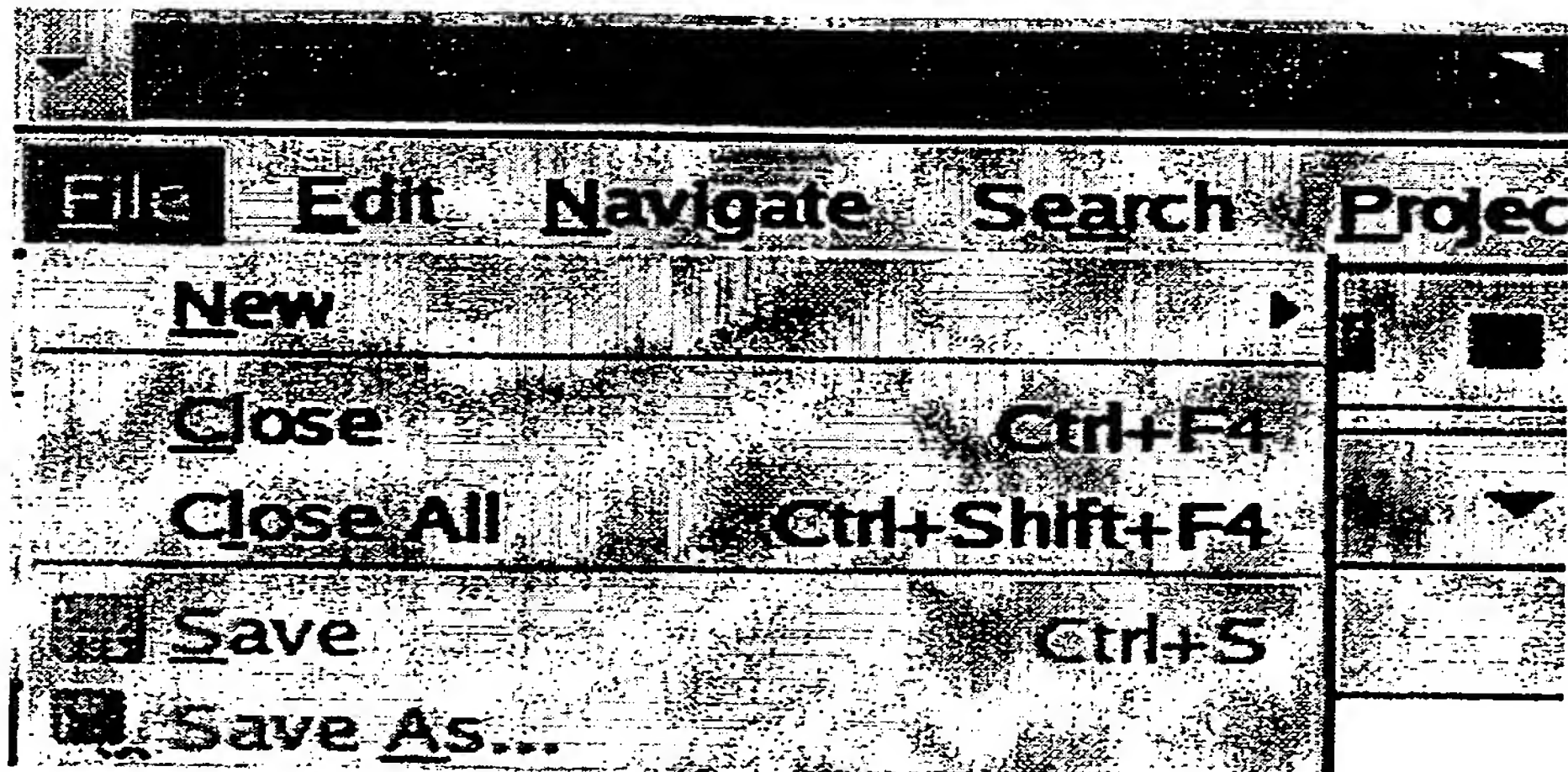


Figure 18

14/15

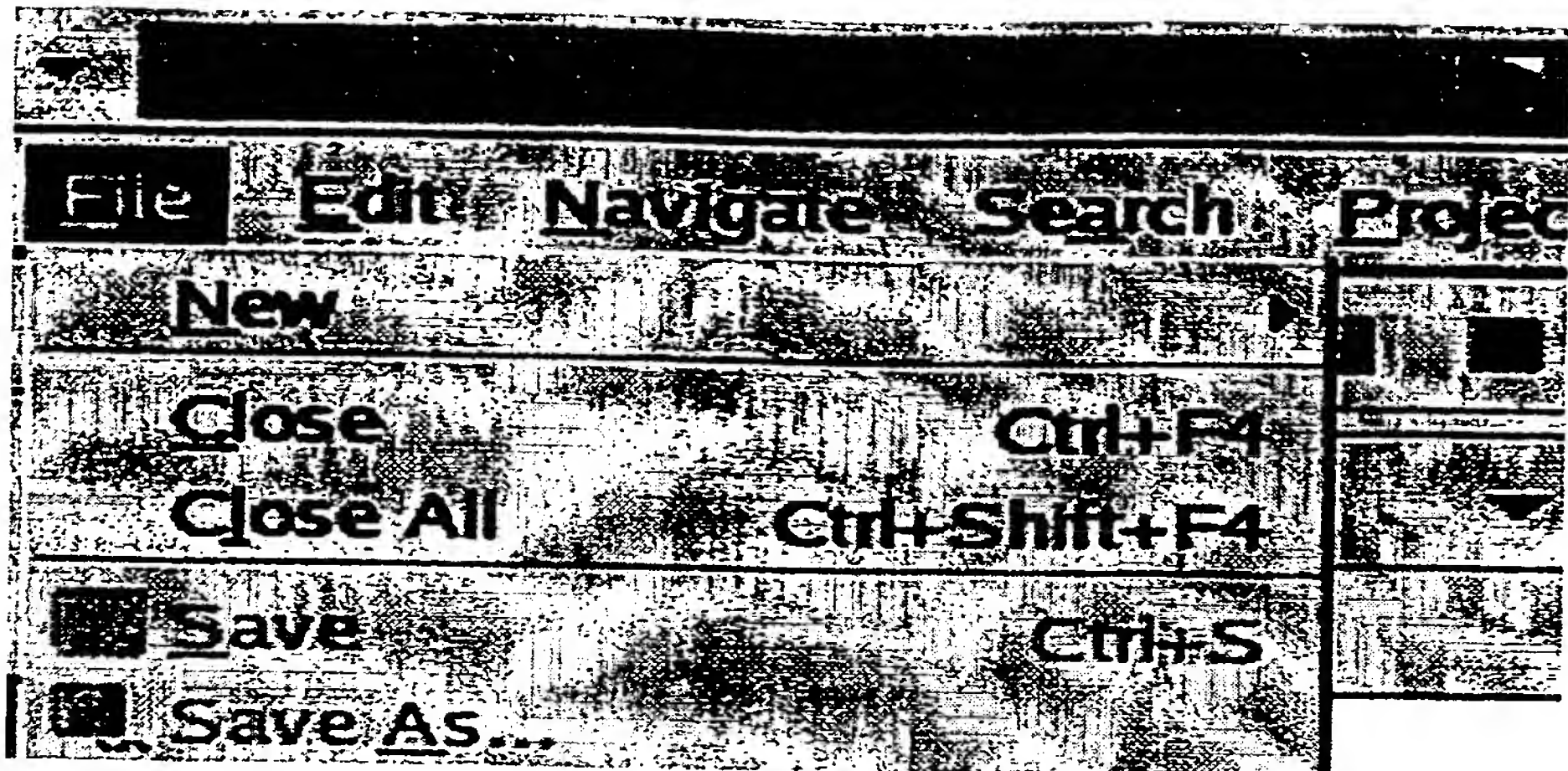


Figure 19

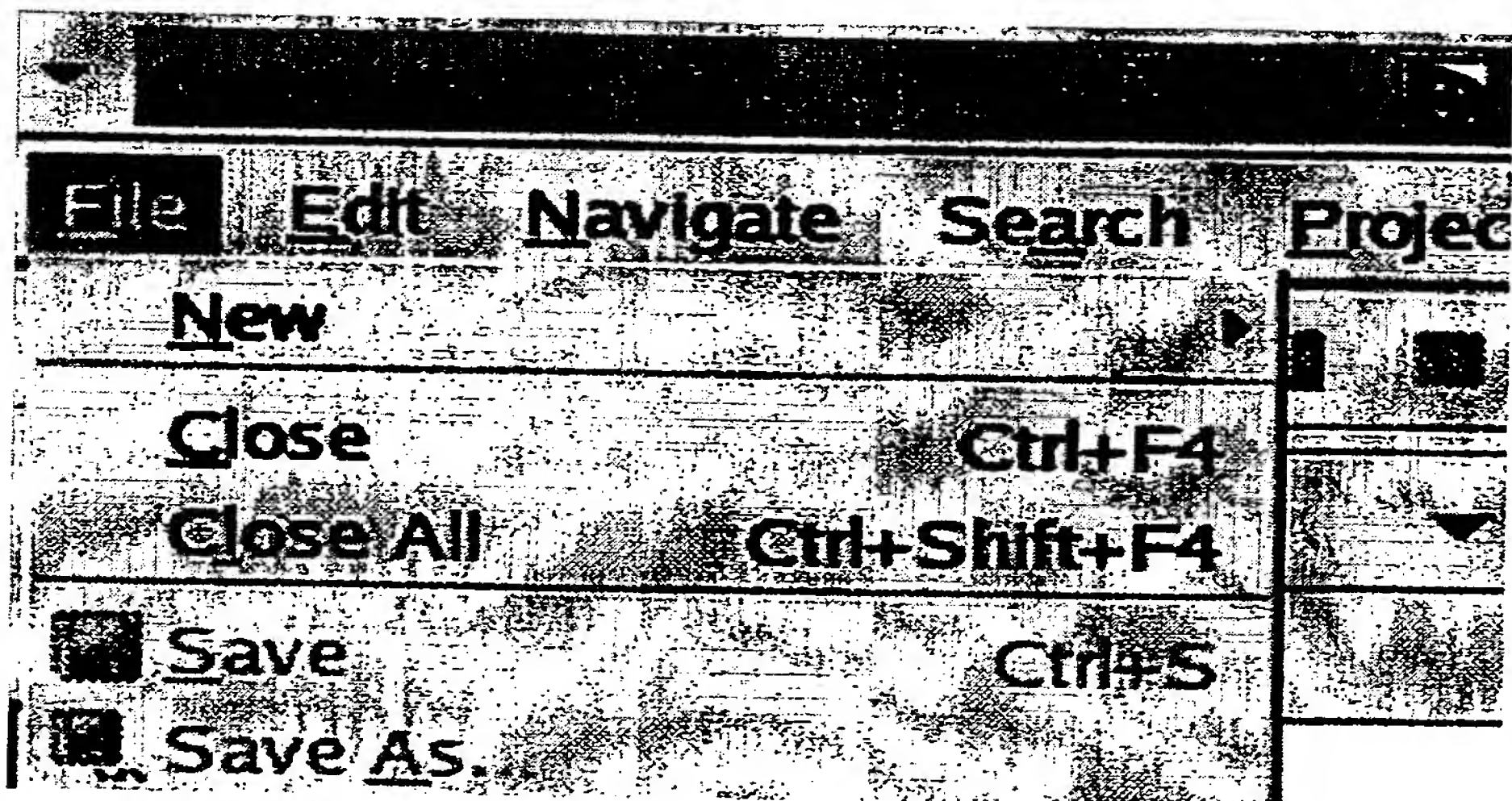
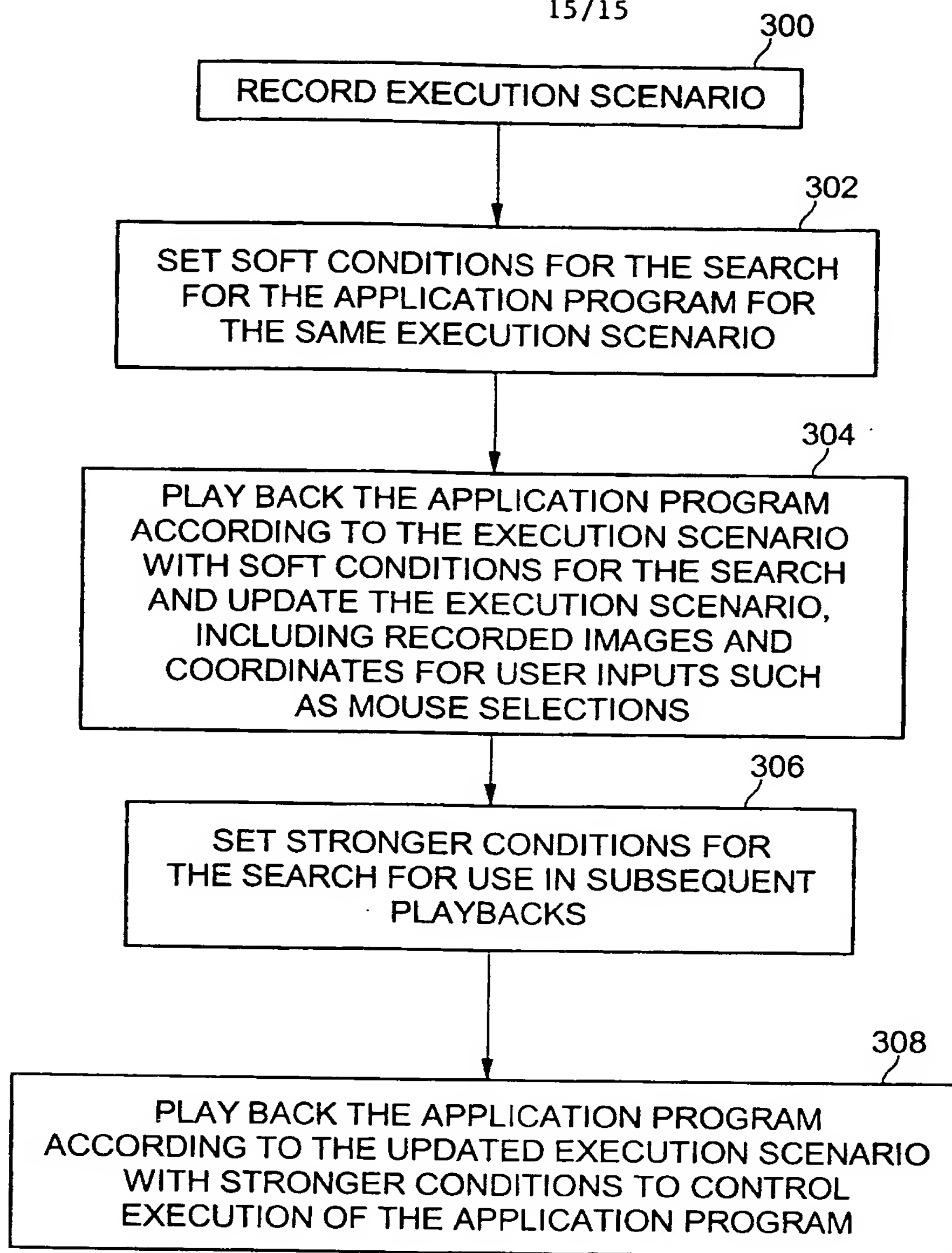


Figure 20

15/15

**Figure 21**

Reducing graphical user interface (GUI) noise maybe achieved by recording a first execution scenario for control of operation of an application program having a GUI during a recording phase of operation of a cognitive control framework system, setting soft conditions for a search for the application program for the first execution scenario, playing back the application program according to the first execution scenario during a playback phase of operation of the cognitive control framework system, updating the first execution scenario to form a second execution scenario to reduce GUI noise conditions observed during playback, including updating recorded images originally generated by the GUI during the recording phase and updating coordinates for user input data, setting stronger conditions for the search for use in subsequent playbacks; and playing back the application program according to the second execution scenario with the stronger conditions for search.

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